ILLINOIS STATE GEOLOGICAL SURVEY
3 3051 00005 2518

Digitized by the Internet Archive
in 2012 with funding from
University of Illinois Urbana-Champaign

http://archive.org/details/majorminortracee82dreh

Geol Survey

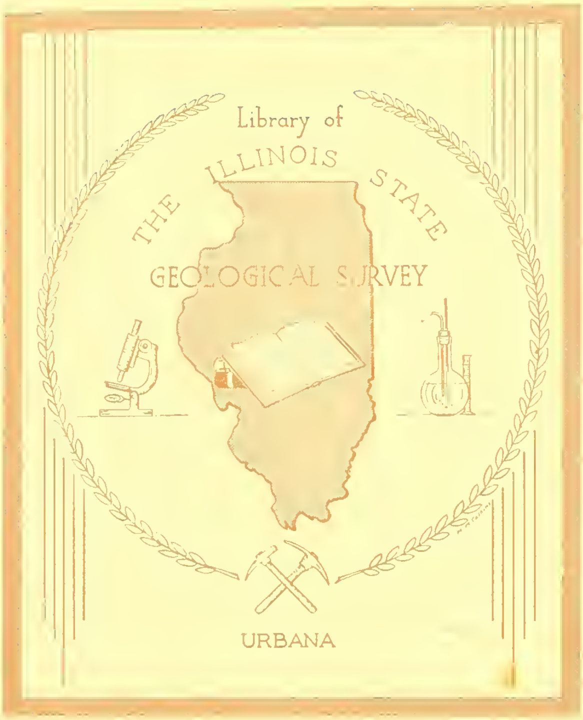
EGN
no. 82
c. 1

ENVIRONMENTAL GEOLOGY NOTES NUMBER 82 AUGUST 1977

MAJOR, MINOR, AND TRACE ELEMENTS OF BOTTOM SEDIMENTS IN LAKE DU QUOIN, JOHNSTON CITY LAKE, AND LITTLE GRASSY LAKE IN SOUTHERN ILLINOIS

G. B. Dreher
C. B. Muchmore
D. W. Stover

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, IL 61801
Jack A. Simon, Chief



Library of
THE ILLINOIS STATE
GEOLOGICAL SURVEY
URBANA

Major, Minor, and Trace Elements of Bottom Sediments in Lake Du Quoin, Johnston City Lake, and Little Grassy Lake in Southern Illinois

G. B. Dreher[1]
C. B. Muchmore[2]
D. W. Stover[3]

ABSTRACT

Bottom sediments from three Southern Illinois lakes, Lake DuQuoin, Johnston City Lake, and Little Grassy Lake, were analyzed chemically for eleven major and minor constituents—SiO_2, Al_2O_3, K_2O, CaO, MgO, Fe_2O_3, TiO_2, MnO, P_2O_5, CO_2, and total carbon; and ten trace elements—B, Cu, Co, Ni, Be, Cr, V, Zn, Sr, and Zr. The less-than-two micrometer clay-size fraction was determined by the pipet method. The sediments from Lake Du Quoin and Johnston City Lake have a high clay content in the upper portions of the bottom sediment cores and a low clay content in the lower portions with a definite transition point demonstrated in twelve of fourteen cores. Above this transition point, copper and zinc have maximum concentrations of 476 and 252 ppm, respectively, in Lake Du Quoin and maximum concentrations of 238 and 259 ppm, respectively, in Johnston City lake sediments. Copper and zinc have been contributed from external sources. The lower portions of the cores from these two lakes and the entire cores from Little Grassy Lake are chemically similar to sediment samples from ancient (Wisconsinan and Holocene) Lake Saline.

---

[1] Illinois State Geological Survey, Urbana, Illinois 61801

[2] Department of Thermal and Environmental Engineering, Southern Illinois University-Carbondale, Carbondale, Illinois 62901

[3] Illinois State Environmental Protection Agency, Marion, Illinois 62959

INTRODUCTION

Sediment cores were collected during the summer of 1974 from three lakes in Southern Illinois—Lake Du Quoin, Johnston City Lake, and Little Grassy Lake—to determine the fate of copper when a lake is treated with copper sulfate as an algacide. Lake Du Quoin and Johnston City Lake have histories of copper sulfate treatment, since until the end of the summer of 1971 both lakes had been sources of drinking water for the nearby communities of Du Quoin and Johnston City, respectively. At that time, because both communities began receiving treated drinking water from the Rend Lake Intercities Water System, copper sulfate treatment was discontinued. Little Grassy Lake, which has no known history of copper sulfate treatment, was used as a control lake.

This report gives data and conclusions for 11 major and minor constituents—SiO_2, Al_2O_3, K_2O, CaO, MgO, Fe_2O_3, TiO_2, MnO, P_2O_5, CO_2, and total carbon; 10 trace elements—B, Cu, Co, Ni, Be, Cr, V, Zn, Sr, and Zr; and the less-than-two micrometer clay content.

EXPERIMENTAL PROCEDURES

Sediment cores were taken with a noncommercial coring device borrowed from the Illinois State Water Survey. The device, which has a stainless steel barrel 5.1 cm in diameter by 91.4 cm long, is equipped with a leather-capped plunger for extruding the cores and a hammer weight for driving the device into the sediment. The extruded cores were cut, on site, into approximately 6.1 cm segments with a polycarbonate knife on a polyethylene covered board and then sealed in polyethylene sample bags. The samples were split radially, and the uppermost splits were used in most cases for clay content analyses. The samples for chemical analysis were air-dried and ground in the laboratory.

Sampling stations with corresponding core numbers are shown in figures 1-3.

X-ray fluorescence analysis and the methods used to determine grain size, total carbon, and carbon dioxide were described by Shimp, Leland, and White (1970).

A direct-reading optical emission spectrometric method for the determinations of trace elements was developed for this work. The mean concentrations of seven major and minor constituents of 174 Lake Michigan bottom sediments collected by Illinois State Geological Survey staff members during the summers of 1969-1971 were calculated. From the mean values a mixture was derived to serve as the matrix (synthetic base) for a series of synthetic sediment standards. The mixture contains the following compounds:

SiO_2	54.06%
$CaCO_3$	21.48%
MgO	8.98%
Al_2O_3	7.38%
K_2CO_3	3.48%
Fe_2O_3	3.44%
Na_2CO_3	1.18%

Synthetic sediment standards using Spex Industries, Inc. SiO_2 and Al_2O_3 Time Saver Standards containing 49 elements were prepared according to table 1. The standards were used to calibrate the individual element input channels of the direct-reading optical emission spectrometer (Jarrell-Ash, Model 750 Atom-counter, 0.75 m focal length), so that the output data for each element was proportional to the relative intensity of light of a particular wavelength. The relative intensity for a given wavelength was, in turn, directly proportional to the concentration in the electrode of the corresponding element. The parameters used in the analysis are listed in table 2.

TABLE 1 - PREPARATION OF SYNTHETIC SEDIMENT STANDARDS

Standard designation	Weight of synthetic base (g)	Concentration of elements in Spex standard (ppm)	Weight of Spex SiO_2 standard (mg)	Weight of Spex Al_2O_3 standard (mg)	Resulting element concentrations (ppm)
1-B	0.66667	1000	293	40	333
1-C	0.90000	1000	88	12	100
1-D	0.90000	333	88	12	33.3
1-E	0.90000	100	88	12	10.0
1-F	0.90000	33.3	88	12	3.3
1-G	0.90000	10.0	88	12	1.0

ILLINOIS STATE
GEOLOGICAL SURVEY
LIBRARY

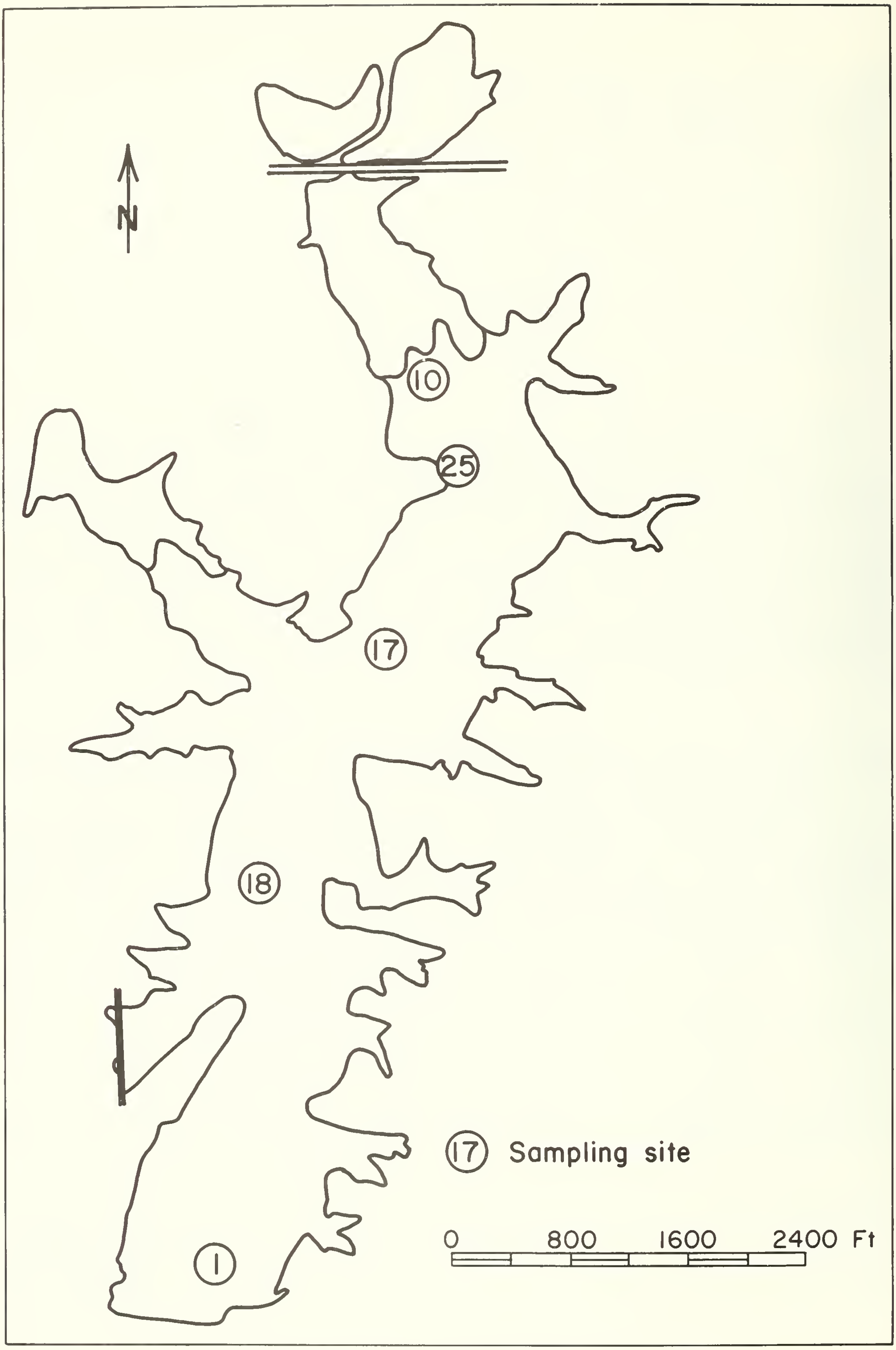


Fig. 1 - Lake Du Quoin: locations of sampling sites.

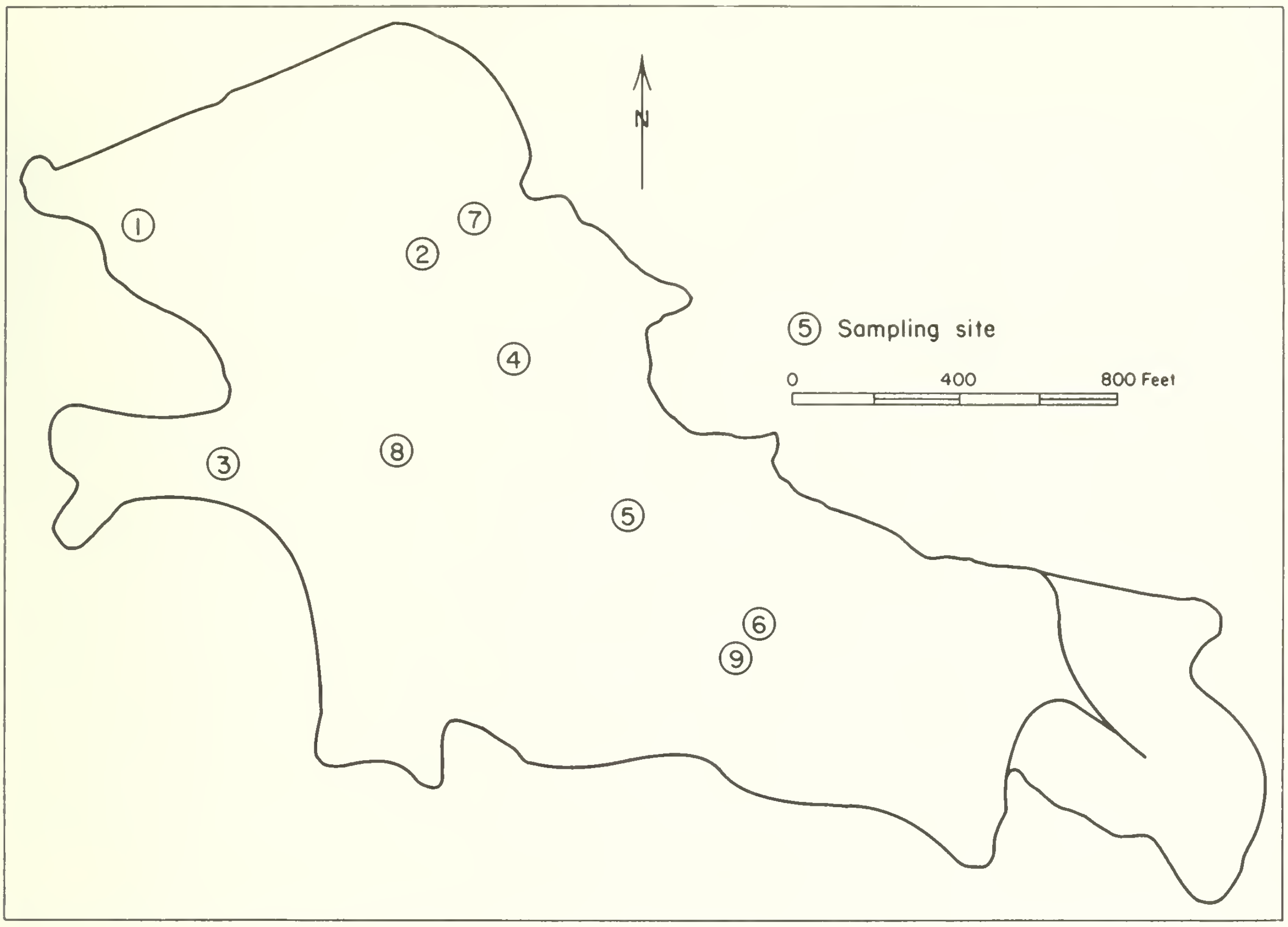


Fig. 2 - Johnston City Lake: locations of sampling sites.

TABLE 2 - OPTIMUM PARAMETERS FOR THE DIRECT-READING OPTICAL EMISSION SPECTROMETER

Sample mixture	4:1:15, sample:$Ba(NO_3)_2$:graphite
Sample charge	15 mg
Graphite powder	National SP-2X
Sample electrode	1/8 in. od, thin-walled crater electrode
Counter electrode	1/8 in. diam., pointed electrode
Electrode gap	6 mm
Arc current	15 ampere, dc
Exposure time	65 sec
Internal standard	Variable, Fe

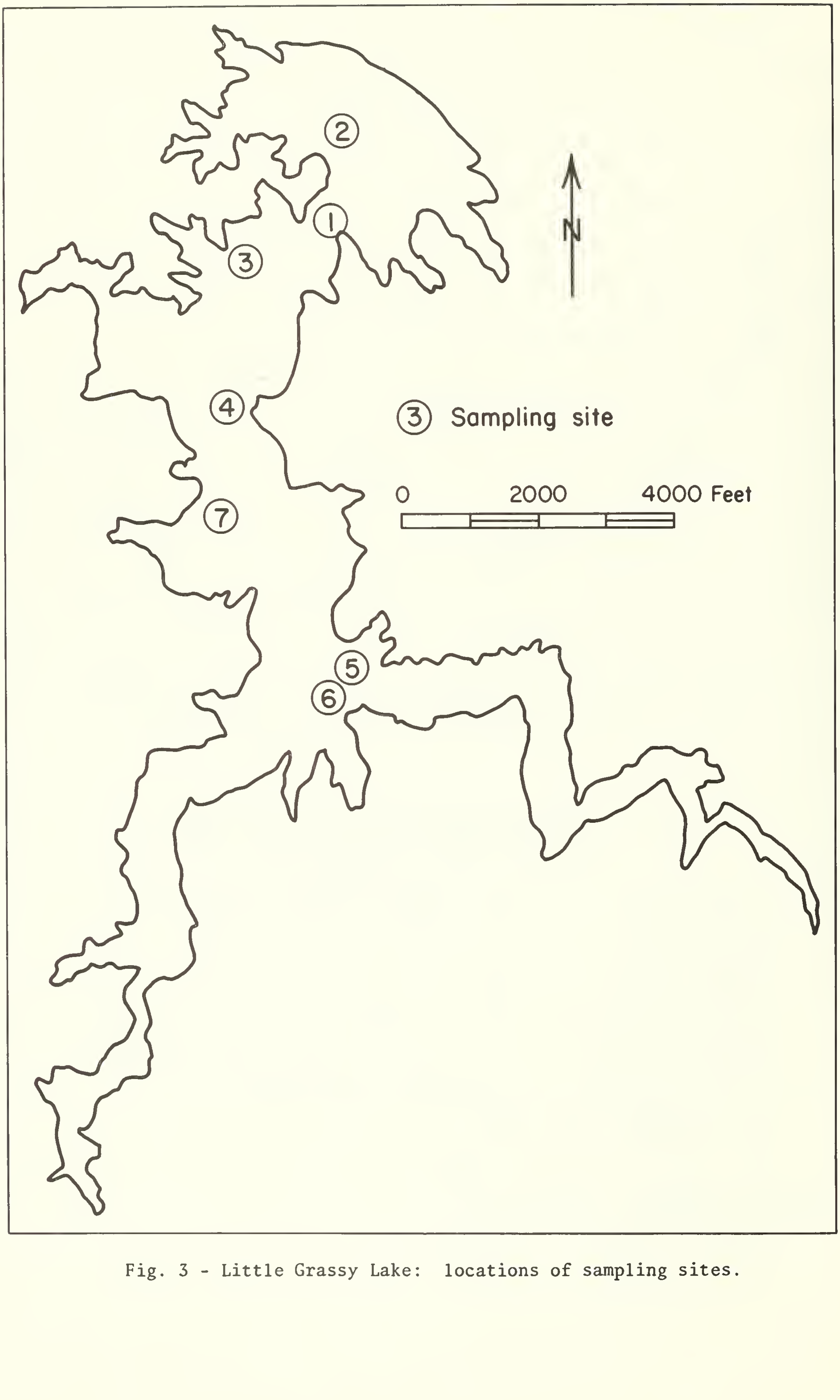


Fig. 3 - Little Grassy Lake: locations of sampling sites.

RESULTS AND DISCUSSION

Compilations of data for Lake Du Quoin, Johnston City Lake, and Little Grassy Lake are provided in tables 3 to 5. The cores are listed in upstream-to-downstream order so that areal trends may be noted. The positions of the clay breaks are indicated by single blank spaces in the individual core data in tables 3 and 4.

The behavior of core contents in Lake Du Quoin and Johnston City Lake contrasts to that of Little Grassy Lake. Every core from Lake Du Quoin shows abrupt changes in the concentrations of SiO_2, Al_2O_3, K_2O, MgO, Fe_2O_3, P_2O_5, and clay content (table 3). The differences in the cores between the positions of the abrupt changes in clay content and the corresponding changes in SiO_2, Al_2O_3, etc. concentrations are due to the fact that, in the laboratory before drying, the samples were split radially instead of longitudinally, and in most cases, the upper halves of the samples were used for analyses of clay content. If the clay change occurs in the upper half of the core segment, the chemical data appears as if the change has taken place in the next higher segment. As the SiO_2 concentration undergoes an abrupt increase across the boundary, the clay content and concentrations of the other mentioned constituents undergo abrupt decreases. Similar behavior is noted for Johnston City Lake for all cores except cores 3 and 6 but is not demonstrated by sediments from Little Grassy Lake.

To illustrate the vertical distributions of the major, minor, and trace elements within a core from each lake, the concentration data for core 17 of Lake Du Quoin, core 4 of Johnston City Lake, and core 4 of Little Grassy Lake are plotted in figures 4, 5, and 6. Other cores from the same lake demonstrate similar vertical distributions. In figures 4 and 5, arrows in the ordinate indicate the depth in the cores at which the clay percentage breaks (the abrupt change in clay content) occur. In general, below the clay percentage breaks, the concentration levels of the constituents are relatively constant.

Six samples from core 1 of Johnston City Lake—three samples immediately above the clay percentage break and three samples immediately below the clay break—were analyzed by X-ray diffraction spectrometry for clay mineral content. All six samples had the same clay mineral content, indicating that the two sediment types originated from similar source materials.

To help understand the differences in the sediment macrostructures, a consideration of the watershed terrain is necessary. A small area of trees surrounds Lake Du Quoin, in Perry County, with houses located around the lake except at the northernmost (upstream) end. Most of the land in the watershed area of approximately 12 square miles (Illinois State Water Survey, unpublished data) appears to be cultivated land and pasturage, with a few small orchards. At Johnston City Lake in Williamson County, the drainage area is approximately 3.8 square miles (Illinois State Water Survey, unpublished data) and contains a larger proportion of woodland than does the Lake Du Quoin watershed.

TABLE 3 - CONCENTRATIONS OF CONSTITUENTS

Station number[b]	Sample number	Depth in core (cm)	SiO_2 (%)	Al_2O_3 (%)	K_2O (%)	CaO (%)	MgO (%)	Fe_2O_3 (%)	TiO_2 (%)	MnO (%)	P_2O_5 (%)	CO_2 (%)
10	D-10-A	0.0-6.1	69.26	11.33	1.66	0.55	0.25	3.38	0.88	0.05	0.11	
10	D-10-B	6.1-12.2	79.44	8.79	1.53	0.50	0.06	1.92	0.94	0.03	0.07	
10	D-10-C	12.2-18.3	79.72	8.43	1.57	0.51	0.06	1.93	0.83	0.04	0.09	
10	D-10-D	18.3-24.4	85.98	8.30	1.54	0.52	0.02	1.86	0.89	0.04	0.06	
10	D-10-E	24.4-30.5	86.46	8.01	1.51	0.46	0.04	1.56	0.86	0.03	0.06	
10	D-10-F	30.5-33.5	85.63	7.43	1.51	0.43	0.01	1.54	0.87	0.03	0.07	0.21
25	D-25-A	0.0-6.1	63.05	13.19	1.61	0.65	0.50	4.97	0.82	0.08	0.34	
25	D-25-B	6.1-12.2	60.12	13.87	1.60	0.68	0.59	5.29	0.82	0.08	0.33	
25	D-25-C	12.2-18.3	61.47	15.01	1.68	0.70	0.50	5.40	0.89	0.08	0.27	0.15
25	D-25-D	18.3-24.4	62.80	13.91	1.61	0.66	0.80	5.03	0.88	0.08	0.27	0.18
25	D-25-E	24.4-30.5	63.47	13.63	1.61	0.61	0.66	4.89	0.85	0.08	0.26	0.11
25	D-25-F	30.5-36.6	62.72	14.15	1.66	0.64	0.63	5.40	0.88	0.08	0.29	
25	D-25-G	36.6-42.7	65.23	13.84	1.70	0.49	0.55	4.80	0.90	0.08	0.21	
25	D-25-H	42.7-48.8	65.00	12.36	1.62	0.45	0.32	4.20	0.84	0.07	0.14	0.19
25	D-25-I	48.8-54.9	66.16	11.60	1.52	0.50	0.51	4.56	0.80	0.08	0.18	
25	D-25-J	54.9-61.0	65.10	12.81	1.61	0.37	0.56	5.21	0.85	0.08	0.20	
25	D-25-K	61.0-67.1	74.91	12.50	1.67	0.45	0.38	4.24	0.86	0.05	0.15	
25	D-25-L	67.1-73.2	73.57	9.32	1.42	0.90	0.27	5.12	0.74	0.07	0.16	
17	D-17-A	0.0-6.1	65.11	16.57	1.74	0.73	0.80	5.68	0.89	0.09	0.23	
17	D-17-B	6.1-12.2	79.83	11.37	1.61	0.55	0.18	3.33	0.76	0.05	0.11	
17	D-17-C	12.2-18.3	81.36	7.92	1.46	0.47	0.09	1.94	0.69	0.03	0.06	
17	D-17-D	18.3-24.4	77.28	8.37	1.48	0.42	0.28	2.14	0.87	0.03	0.06	
17	D-17-E	24.4-30.5	80.88	8.15	1.44	0.42	0.04	2.38	0.83	0.03	0.06	
17	D-17-F	30.5-36.6	78.67	7.70	1.41	0.38	0.11	1.99	0.79	0.04	0.05	
17	D-17-G	36.6-42.7	78.77	7.64	1.42	0.42	0.03	1.98	0.80	0.03	0.05	
17	D-17-H	42.7-48.8	79.39	7.80	1.43	0.40	0.09	1.90	0.80	0.02	0.06	
17	D-17-I	48.8-54.9	79.42	8.06	1.46	0.41	0.15	1.81	0.82	0.02	0.06	
18	D-18-A	0.0-6.1	60.04	17.00	1.66	0.69	0.98	5.82	0.87	0.09	0.32	
18	D-18-B	6.1-12.2	60.44	15.64	1.66	0.74	0.59	5.59	0.84	0.09	0.24	
18	D-18-C	12.2-18.3	62.00	14.79	1.68	0.64	0.97	5.18	0.84	0.08	0.15	
18	D-18-D	18.3-24.4	66.73	15.76	1.77	0.55	0.92	4.85	0.94	0.07	0.16	
18	D-18-E	24.4-30.5	75.09	10.93	1.61	0.44	0.43	2.64	0.90	0.04	0.10	
18	D-18-F	30.5-36.6	78.66	8.89	1.55	0.40	0.47	2.15	0.86	0.03	0.04	
18	D-18-G	36.6-42.7	80.24	9.27	1.55	0.39	0.40	2.21	0.84	0.03	0.13	
18	D-18-H	42.7-48.8	79.24	9.43	1.55	0.38	0.13	2.42	0.62	0.04	0.07	
18	D-18-I	48.8-54.9	81.19	8.70	1.47	0.40	0.32	1.99	0.82	0.03	0.03	.17
18	D-18-J	54.9-61.0	82.01	8.27	1.46	0.51	0.01	1.87	0.78	0.01	0.07	
1	D-1-A	0.0-6.1	58.87	15.01	1.65	0.68	0.70	6.32	0.93	0.14	0.39	0.29
1	D-1-B	6.1-12.2	65.91	12.45	1.62	0.68	0.18	4.23	0.74	0.07	0.17	0.21
1	D-1-C	12.2-18.3	75.70	11.81	1.69	0.80	0.29	3.31	0.96	0.06	0.21	
1	D-1-D	18.3-24.4	81.34	8.76	1.52	0.48	0.08	1.99	0.90	0.04	0.14	
1	D-1-E	24.4-30.5	81.64	13.02	1.51	0.54	0.35	1.85	0.91	0.03	0.13	
1	D-1-F	30.5-36.6	80.80	7.91	1.45	0.49	0.05	1.87	0.77	0.03	0.08	
1	D-1-G	36.6-42.7	82.91	8.38	1.46	0.48	0.05	1.84	0.86	0.02	0.05	
1	D-1-H	42.7-48.8	82.03	7.92	1.40	0.47	0.07	1.87	0.75	0.03	0.06	
1	D-1-I	48.8-54.9	80.53	7.39	1.41	0.47	0.03	1.69	0.80	0.02	0.03	0.12
1	D-1-J	54.9-61.0	82.28	7.92	1.44	0.48	0.05	1.86	0.79	0.03	0.04	
1	D-1-K	61.0-64.0	83.63	8.13	1.52	0.48	0.10	1.86	0.80	0.03	0.04	

---

[a] Spaces within sample numbers designate location of clay breaks.

[b] Listed in upstream to downstream order.

N CORES FROM LAKE DU QUOIN[a]

otal arbon (%)	B (ppm)	Cu (ppm)	Co (ppm)	Ni (ppm)	Be (ppm)	Cr (ppm)	V (ppm)	Zn (ppm)	Sr (ppm)	Zr (ppm)	<2 μm clay (%)
.41	55	145	16	34	3.1	65	59	141	118	314	41.1
.92	93	13	8.0	28	2.8	41	42	91	91	306	21.8
.27	84	9.3	8.2	26	2.6	39	44	81	98	313	16.2
.45	68	7.1	7.3	22	2.1	36	32	66	110	268	13.8
.50	77	6.3	8.7	15	2.1	34	32	42	89	270	12.3
.11	90	7.0	8.5	13	1.4	39	28	42	92	336	13.5
.36	52	164	15	30	3.2	57	70	203	101	279	45.8
.52	40	266	14	31	2.1	58	82	211	78	296	46.1
.43	41	255	15	34	2.5	69	89	227	96	294	49.2
.39	46	280	13	29	2.1	59	73	194	94	262	48.7
.11	42	367	16	34	3.0	69	91	164	100	281	42.7
.30	41	386	14	30	3.1	59	75	200	92	287	46.0
.06	49	233	16	33	2.9	61	71	186	93	290	45.5
.63	58	270	15	28	3.1	54	68	203	108	290	38.4
.48	53	354	14	29	2.9	64	65	157	110	289	35.4
.43	44	225	13	30	3.1	64	70	164	104	274	48.6
.32	47	247	13	24	3.0	62	50	140	122	269	48.5
.13	51	51	18	30	3.4	48	63	123	76	305	24.3
.39	38	375	16	36	3.3	75	106	224	89	274	54.4
.59	53	211	12	26	2.9	45	70	138	79	312	39.4
.73	69	11	9.6	14	2.1	33	35	58	89	304	17.6
.83	84	6.0	6.2	17	2.5	32	37	84	73	329	14.2
.55	75	5.3	4.8	16	1.7	33	31	61	80	321	16.4
.43	85	7.5	7.8	20	1.9	38	34	51	84	323	17.5
.38	90	7.1	8.1	16	1.6	36	33	48	82	326	14.6
.30	84	7.7	9.0	13	1.9	39	33	47	91	306	11.7
.25	79	8.2	8.0	11	1.6	36	34	43	80	308	14.1
.79	43	408	18	35	4.4	63	118	242	63	306	64.4
.44	45	476	17	36	4.4	63	103	239	70	304	61.9
.43	38	404	16	45	3.7	63	133	195	90	390	52.1
.69	42	386	15	41	3.8	68	134	170	96	376	63.7
.89	59	63	11	30	2.9	56	81	96	101	399	35.9
.90	67	11	9.2	23	2.7	45	58	67	103	396	24.8
.99	64	11	11	27	3.0	42	61	64	105	399	23.1
.72	62	9.4	9.2	22	2.6	42	55	62	94	394	19.0
.78	69	7.8	12	20	3.2	41	53	52	104	390	17.6
.38	96	<3.0	8.8	20	3.0	37	47	48	95	383	15.6
.14	52	454	14	33	3.5	59	113	252	71	313	67.6
.10	62	277	12	30	2.7	65	85	168	109	305	39.6
.52	82	98	9.0	27	1.9	55	84	158	124	380	26.1
.30	84	13	6.6	26	1.4	43	51	102	119	366	17.4
.87	78	14	9.3	26	2.0	47	30	90	105	338	16.3
.30	84	10	8.4	21	1.5	47	23	80	106	306	15.8
.42	81	10	9.1	18	1.6	38	25	63	94	299	15.2
.34	89	10	9.3	16	1.9	46	28	73	99	324	12.9
.50	78	10	11	21	2.1	44	25	77	112	306	11.8
.37	90	10	9.0	16	1.9	48	29	47	100	332	13.0
.47	92	12	11	18	2.1	44	32	64	93	310	13.1

TABLE 4 - CONCENTRATIONS OF CONSTITUENTS

Station number[b]	Sample number	Depth in core (cm)	SiO_2 (%)	Al_2O_3 (%)	K_2O (%)	CaO (%)	MgO (%)	Fe_2O_3 (%)	TiO_2 (%)	MnO (%)	P_2O_5 (%)	CO_2 (%)
6	J-6-A	0.0-6.1	59.95	15.75	1.81	0.54	0.86	6.41	0.86	0.10	0.24	
6	J-6-B	6.1-12.2	61.76	16.04	1.85	0.65	0.95	6.19	0.92	0.09	0.11	
6	J-6-C	12.2-18.3	65.12	14.32	1.84	0.51	0.74	5.61	0.91	0.07	0.11	0.18
6	J-6-D	18.3-24.4	63.84	14.58	1.82	0.44	1.03	5.14	0.89	0.06	0.21	0.16
6	J-6-E	24.4-30.5	65.45	15.00	1.90	0.46	1.08	5.18	0.95	0.06	0.17	0.14
6	J-6-F	30.5-36.6	70.40	13.20	1.84	0.32	0.80	4.23	0.98	0.05	0.14	0.15
6	J-6-G	36.6-39.6	76.90	10.39	1.36	0.31	0.69	3.30	0.89	0.05	0.11	
9	J-9-A	0.0-6.1	70.02	14.50	1.84	0.38	0.62	4.94	0.95	0.07	0.07	0.05
9	J-9-B	6.1-12.2	85.97	8.61	1.56	0.31	0.20	2.03	0.82	0.02	0.08	0.08
9	J-9-C	12.2-18.3	86.68	7.84	1.57	0.35	0.30	2.08	0.88	0.03	0.03	0.28
9	J-9-D	18.3-24.4	87.40	7.99	1.58	0.34	0.10	2.07	0.92	0.03	0.03	0.13
9	J-9-E	24.4-30.5	87.76	7.82	1.50	0.34	0.10	1.96	0.88	0.03	0.002	
9	J-9-F	30.5-36.6	84.78	8.01	1.51	0.32	0.04	2.12	0.87	0.03	0.05	0.09
9	J-9-G	36.6-42.7	84.76	7.80	1.45	0.31	0.21	2.07	0.83	0.03	0.001	0.10
9	J-9-H	42.7-45.7	85.75	7.95	1.48	0.31	0.30	2.47	0.80	0.03	0.06	
5	J-5-A	0.0-6.1	57.74	17.24	1.96	0.62	1.15	6.88	0.94	0.10	0.22	
5	J-5-B	6.1-12.2	61.40	17.13	2.01	0.48	0.83	6.17	0.98	0.08	0.19	
5	J-5-C	12.2-18.3	62.75	15.66	2.01	0.43	1.33	5.70	1.01	0.09	0.20	
5	J-5-D	18.3-24.4	64.36	15.24	2.02	0.39	0.79	5.45	0.96	0.07	0.19	
5	J-5-E	24.4-30.5	67.51	14.82	1.97	0.38	0.82	5.04	0.96	0.06	0.13	
5	J-5-F	30.5-36.6	68.80	13.27	1.88	0.35	0.68	4.21	0.91	0.05	0.13	
5	J-5-G	36.6-42.7	64.16	16.59	2.01	0.32	0.88	5.44	1.01	0.08	0.18	
5	J-5-H	42.7-48.8	86.06	5.70	1.07	0.26	0.14	1.63	0.54	0.02	0.06	
5	J-5-I	48.8-54.9	85.70	6.76	1.32	0.30	0.47	1.87	0.69	0.01	0.07	
5	J-5-J	54.9-57.9	85.92	7.04	1.32	0.27	0.43	1.78	0.70	0.03	0.07	
4	J-4-A	0.0-3.0	63.97	14.25	1.82	0.43	0.72	5.67	0.93	0.09	0.13	
4	J-4-B	3.0-6.1	59.25	17.05	2.04	0.36	1.03	6.83	0.95	0.11	0.15	
4	J-4-C	6.1-12.2	62.45	16.75	2.09	0.32	1.12	6.52	1.00	0.11	0.16	
4	J-4-D	12.2-18.3	68.44	15.12	1.95	0.23	0.89	5.18	0.98	0.08	0.12	
4	J-4-E	18.3-24.4	81.41	8.58	1.62	0.24	0.07	1.94	0.93	0.03	0.08	
4	J-4-F	24.4-30.5	80.28	7.99	1.57	0.24	0.09	1.96	0.92	0.04	0.12	
4	J-4-G	30.5-36.6	81.58	8.77	1.51	0.28	0.25	2.14	0.85	0.03	0.07	
4	J-4-H	36.6-42.7	81.97	9.14	1.50	0.30	0.19	2.12	0.83	0.02	0.02	
4	J-4-I	42.7-48.8	82.14	9.67	1.47	0.27	0.41	2.06	0.86	0.03	0.08	
4	J-4-J	48.8-54.9	82.49	9.17	1.51	0.26	0.22	2.15	0.91	0.02	0.05	
4	J-4-K	54.9-61.0	83.63	8.72	1.55	0.26	0.03	2.19	0.93	0.02	0.01	
4	J-4-L	61.0-67.1	84.11	8.19	1.56	0.24	0.16	2.01	0.94	0.02	0.02	
4	J-4-M	67.1-70.1	66.91	15.43	1.97	0.35	0.97	5.15	0.99	0.07	0.11	
8	J-8-A	0.0-6.1	61.26	17.86	2.04	0.44	1.27	6.80	1.00	0.09	0.09	
8	J-8-B	6.1-12.2	62.89	17.40	2.03	0.36	1.01	6.43	1.03	0.09	0.10	
8	J-8-C	12.2-18.3	63.95	16.79	2.01	0.33	1.00	6.09	0.77	0.08	0.09	0.28
8	J-8-D	18.3-24.4	83.28	7.72	1.43	0.52	0.32	2.25	0.83	0.03	0.04	
8	J-8-E	24.4-30.5	81.74	7.91	1.49	0.42	0.30	2.24	0.84	0.03	0.04	0.30
8	J-8-F	30.5-36.6	84.05	7.87	1.44	0.29	0.25	1.94	0.86	0.02	0.04	0.20
8	J-8-G	36.6-42.7	83.97	8.10	1.43	0.30	0.35	2.13	0.90	0.02	0.02	
8	J-8-H	42.7-48.8	84.65	8.08	1.43	0.30	0.23	2.01	0.95	0.03	0.02	0.13
8	J-8-I	48.8-54.9	81.84	8.45	1.43	0.30	0.11	2.05	0.86	0.03	0.005	0.17
8	J-8-J	54.9-61.0	83.31	8.27	1.49	0.31	0.07	2.24	0.89	0.03	0.004	
8	J-8-K	61.0-67.1	84.88	7.84	1.49	0.30	0.38	1.82	0.88	0.03	0.005	0.19
8	J-8-L	67.1-73.2	85.03	8.42	1.47	0.30	0.22	2.10	0.87	0.04	0.003	0.18
8	J-8-M	73.2-76.2	87.81	8.12	1.51	0.27	0.35	1.88	0.85	0.03	0.01	0.08

---

[a] Spaces within sample numbers designate location of clay breaks.

[b] Listed in upstream to downstream order.

IN CORES FROM JOHNSTON CITY LAKE[a]

Total carbon (%)	B (ppm)	Cu (ppm)	Co (ppm)	Ni (ppm)	Be (ppm)	Cr (ppm)	V (ppm)	Zn (ppm)	Sr (ppm)	Zr (ppm)	<2 μm clay (%)
0.024	43	142	16	42	4.6	63	119	161	95	354	21.4
2.96	51	238	17	42	4.9	57	119	166	95	356	44.2
2.50	55	147	16	38	4.4	57	111	136	91	349	
1.45	54	22	15	36	4.6	54	100	137	90	360	38.2
1.13	60	21	16	38	4.7	59	108	139	100	350	40.1
1.00	67	20	12	31	4.1	52	91	97	87	374	33.1
1.06	73	11	10	24	3.4	41	63	60	81	373	24.3
1.14	61	19	14	36	5.1	55	101	113	98	375	16.2
0.65	97	4.8	6.6	18	3.0	36	38	33	86	389	10.3
1.05	88	5.0	8.2	21	4.0	32	37	28	89	395	12.8
0.54	110	5.9	7.6	26	4.0	36	36	29	90	387	11.3
0.80	98	6.6	8.2	27	4.7	37	38	22	105	394	9.5
0.57	94	5.7	9.0	24	4.9	37	46	32	109	396	11.9
0.35	89	3.7	6.0	19	4.0	33	49	26	97	398	16.6
0.10	92	4.2	6.6	17	4.7	35	44	34	87	396	13.5
2.86	35	219	15	52	7.3	79	171	141	108	369	22.7
1.93	41	113	16	51	6.4	68	144	135	117	389	24.0
1.33	41	19	15	44	6.4	68	117	142	106	370	42.0
1.13	53	22	14	45	7.4	63	114	134	102	377	50.6
1.05	55	23	12	42	6.1	66	115	100	115	378	37.4
0.84	59	19	12	38	6.4	62	94	82	114	387	37.0
1.40	47	20	16	47	7.1	65	119	139	99	371	51.6
0.87	90	6.1	11	15	3.5	22	26	47	52	296	31.9
0.47	93	5.8	7.6	15	2.9	32	31	32	75	350	16.7
0.25	117	5.6	9.6	15	3.4	33	35	28	78	360	12.8
2.53	44	138	15	48	5.1	68	132	139	104	375	16.3
2.06	33	57	22	52	6.2	69	152	162	102	351	28.8
1.49	28	29	21	50	5.4	68	157	154	108	362	25.5
1.05	39	17	17	39	5.2	66	123	120	95	352	48.2
0.59	66	5.2	9.6	24	3.4	41	58	39	104	393	34.2
0.84	67	7.6	10	23	3.8	44	48	40	103	403	16.5
0.75	78	5.6	7.8	23	3.8	42	54	45	99	394	14.1
1.12	73	8.1	8.6	24	4.0	40	53	47	90	388	17.6
0.64	80	7.8	7.7	23	2.3	42	57	39	95	395	16.8
0.28	81	7.4	9.8	22	3.3	37	53	43	87	385	10.9
0.28	74	5.9	8.7	17	3.1	42	47	30	92	381	17.4
0.49	73	5.9	8.3	15	3.2	41	52	27	105	385	12.3
0.96	49	31	16	44	5.2	66	126	104	99	366	26.9
1.68	34	32	18	48	5.3	66	128	167	91	354	53.8
1.41	44	34	13	46	5.5	65	133	132	93	334	48.4
1.24	40	26	16	44	5.1	67	136	130	92	334	43.5
0.70	97	6.4	6.7	18	3.5	42	43	32	79	366	16.6
0.37	84	6.1	6.1	20	3.8	38	49	25	90	384	12.1
0.36	111	6.7	6.3	19	3.7	34	48	25	89	386	11.7
0.34	89	6.3	3.6	19	3.3	35	43	26	86	377	15.2
0.35	83	6.9	5.0	20	3.3	35	44	18	97	385	9.6
0.44	73	7.3	5.5	22	3.8	40	46	24	86	371	15.7
0.30	90	4.3	9.2	19	4.5	31	41	39	86	393	15.6
0.21	105	3.5	7.5	17	3.3	34	36	24	88	380	12.4
0.14	91	3.4	7.7	16	3.2	36	38	30	82	389	39.2
0.20	103	3.7	10	16	3.8	33	36	21	79	385	43.9

Station number[b]	Sample number	Depth in core (cm)	SiO_2 (%)	Al_2O_3 (%)	K_2O (%)	CaO (%)	MgO (%)	Fe_2O_3 (%)	TiO_2 (%)	MnO (%)	P_2O_5 (%)	CO_2 (%)
3	J-3-A	0.0-3.0	78.17	10.00	1.69	0.27	0.25	2.54	0.91	0.04	0.11	
3	J-3-B	3.0-6.1	84.87	9.11	1.69	0.30	0.24	2.02	0.89	0.04	0.03	
3	J-3-C	6.1-12.2	81.52	7.88	1.64	0.30	0.20	1.93	0.85	0.04	0.10	
3	J-3-D	12.2-18.3	81.27	8.57	1.66	0.31	0.59	2.20	0.84	0.04	0.04	
3	J-3-E	18.3-24.4	81.61	8.34	1.69	0.27	0.35	2.11	0.87	0.04	0.07	
3	J-3-F	24.4-30.5	82.36	7.90	1.73	0.33	0.23	2.19	0.84	0.05	0.12	
3	J-3-G	30.5-36.6	81.13	7.96	1.68	0.22	0.27	2.04	0.84	0.04	0.09	
3	J-3-H	36.6-42.7	81.49	8.34	1.74	0.14	0.08	2.42	0.92	0.04	0.06	
3	J-3-I	42.7-45.7	83.26	8.82	1.74	0.17	0.35	2.41	0.93	0.04	0.11	
7	J-7-A	0.0-6.1	59.44	16.09	1.93	0.44	0.85	6.07	0.96	0.09	0.21	0.22
7	J-7-B	6.1-12.2	67.65	15.20	1.90	0.38	0.85	5.19	0.93	0.07	0.22	0.13
7	J-7-C	12.2-18.3	83.12	7.77	1.56	0.32	0.57	1.88	0.84	0.01	0.15	0.12
7	J-7-D	18.3-24.4	81.65	8.08	1.60	0.33	0.19	2.00	0.89	0.02	0.02	
7	J-7-E	24.4-30.5	83.07	8.45	1.61	0.33	0.28	1.92	0.87	0.02	0.03	0.16
7	J-7-F	30.5-36.6	85.78	7.51	1.55	0.35	0.16	1.70	0.81	0.02	0.01	0.10
7	J-7-G	36.6-42.7	81.86	8.15	1.55	0.36	0.10	1.79	0.94	0.02	0.06	0.04
7	J-7-H	42.7-48.8	84.30	8.88	1.60	0.31	0.25	2.08	0.94	0.03	0.03	0.17
7	J-7-I	48.8-54.9	81.67	8.13	1.56	0.33	0.16	1.85	0.92	0.02	0.05	0.09
2	J-2-A	0.0-6.1	54.31	16.89	1.96	0.47	1.05	7.07	0.93	0.11	0.23	
2	J-2-B	6.1-12.2	60.13	17.72	2.01	0.20	1.00	6.20	0.98	0.10	0.20	
2	J-2-C	12.2-18.3	61.38	17.13	1.98	0.07	0.82	5.80	0.92	0.10	0.20	
2	J-2-D	18.3-24.4	79.33	10.23	1.63	0.02	0.48	2.62	0.88	0.04	0.07	
2	J-2-E	24.4-30.5	84.48	7.40	1.54	0.07	0.42	1.71	0.89	0.04	0.02	0.26
2	J-2-F	30.5-36.6	85.63	8.19	1.59	0.04	0.07	1.85	0.91	0.03	0.07	
2	J-2-G	36.6-42.7	84.65	7.42	1.50	0.30	0.41	1.77	0.86	0.05	0.04	
2	J-2-H	42.7-48.8	85.71	7.06	1.48	0.30	0.22	1.70	0.87	0.04	0.04	
2	J-2-I	48.8-54.9	87.12	7.07	1.39	0.26	0.20	1.45	0.81	0.04	0.07	
2	J-2-J	54.9-61.0	82.39	8.40	1.53	0.26	0.20	1.97	0.94	0.03	0.07	
2	J-2-K	61.0-67.1	80.26	8.27	1.52	0.28	0.16	2.13	0.94	0.04	0.07	
2	J-2-L	67.1-73.2	80.97	8.55	1.50	0.25	0.12	2.30	0.91	0.41	0.07	
2	J-2-M	73.2-79.3	80.25	8.07	1.51	0.28	0.30	2.38	0.88	0.45	0.06	
1	J-1-A	0.0-6.1	47.96	14.79	1.64	0.64	1.00	6.67	0.77	0.10	0.23	0.24
1	J-1-B	6.1-12.2	58.53	17.44	2.02	0.46	1.06	7.37	0.94	0.11	0.27	0.14
1	J-1-C	12.2-18.3	57.64	17.39	1.98	0.26	0.98	6.97	0.92	0.10	0.24	0.10
1	J-1-D	18.3-24.4	58.73	17.28	2.07	0.34	0.85	6.92	0.93	0.10	0.21	
1	J-1-E	24.4-30.5	59.68	16.42	2.03	0.33	0.90	6.32	0.94	0.09	0.18	
1	J-1-F	30.5-36.6	59.68	17.14	2.03	0.36	0.88	6.50	0.98	0.10	0.21	
1	J-1-G	36.6-42.7	66.86	14.93	2.00	0.26	0.44	5.00	0.96	0.08	0.15	0.10
1	J-1-H	42.7-48.8	65.54	15.44	1.95	0.39	0.99	5.60	0.95	0.09	0.15	0.17
1	J-1-I	48.8-54.9	83.01	8.35	1.60	0.32	0.25	2.23	0.86	0.03	0.01	
1	J-1-J	54.9-61.0	84.90	7.91	1.52	0.26	0.18	1.70	0.84	0.03	0.09	
1	J-1-K	61.0-67.1	82.77	8.72	1.55	0.31	0.25	2.20	0.91	0.04	0.02	0.23
1	J-1-L	67.1-73.2	85.46	8.56	1.44	0.22	0.30	2.40	0.87	0.05	0.07	0.20
1	J-1-M	73.2-79.3	83.36	8.24	1.47	0.27	0.18	2.11	0.87	0.04	0.04	
1	J-1-N	79.3-85.4	80.95	8.47	1.47	0.34	0.36	2.41	0.84	0.05	0.09	0.20

---

[a] Spaces within sample numbers designate location of clay breaks.

[b] Listed in upstream to downstream order.

Continued

Total carbon (%)	B (ppm)	Cu (ppm)	Co (ppm)	Ni (ppm)	Be (ppm)	Cr (ppm)	V (ppm)	Zn (ppm)	Sr (ppm)	Zr (ppm)	<2 µm clay (%)
2.07	63	12	8.7	34	4.7	44	85	47	104	405	30.8
0.90	72	7.2	4.6	21	3.5	43	56	41	99	399	18.0
0.50	73	6.9	6.6	21	3.8	41	57	30	105	398	18.4
0.88	79	7.0	8.0	27	4.8	40	67	25	103	400	18.0
0.85	80	8.0	7.2	28	4.9	48	68	27	108	416	17.0
0.64	79	6.6	11	22	3.4	43	53	28	110	382	18.5
0.70	75	6.3	8.8	20	2.7	38	54	29	116	381	15.9
0.84	72	6.7	9.6	23	2.8	46	57	38	111	391	12.0
0.66	69	7.1	12	24	3.4	49	56	47	97	401	16.0
1.52	46	38	17	44	5.2	57	121	159	79	333	60.7
1.74	46	26	18	40	4.8	60	122	114	95	348	47.0
0.88	86	8.0	8.7	20	3.1	35	41	38	94	390	13.6
0.94	83	7.3	8.6	20	3.1	40	44	41	91	387	14.2
0.62	84	8.2	9.1	21	3.4	39	44	39	90	381	14.8
0.46	83	5.6	8.2	23	3.2	41	36	31	89	369	15.6
0.23	76	5.8	7.1	20	2.7	42	41	26	97	388	11.5
0.58	76	6.1	8.3	18	3.4	47	43	26	96	379	7.9
0.70	82	6.0	8.0	18	3.4	41	42	26	97	399	11.9
1.88	31	69	19	58	6.8	69	165	142	88	350	61.9
1.38	23	38	19	56	5.5	68	157	99	98	345	58.1
0.70	24	32	19	49	6.0	71	155	101	103	347	48.1
0.90	64	13	9.5	28	4.1	47	68	42	95	386	46.2
0.53	76	8.5	8.2	21	4.1	36	44	23	100	400	10.8
0.63	77	8.5	7.5	22	4.2	42	46	22	104	397	11.2
0.64	75	5.0	6.0	22	3.3	43	47	28	107	373	13.0
0.36	72	4.8	4.3	26	3.2	38	47	20	102	391	14.3
0.45	74	5.0	4.5	23	3.0	39	39	25	106	388	9.6
0.38	65	6.8	6.6	24	3.6	44	57	32	108	387	11.1
0.51	60	5.5	5.8	23	3.9	43	57	23	101	392	13.8
0.44	60	6.0	6.0	19	3.6	35	52	29	101	391	11.1
0.65	70	6.0	7.5	22	4.2	44	59	34	91	396	16.8
10.33	42	191	14	61	7.0	73	160	144	110	370	38.5
1.94	51	18	21	51	5.8	66	136	259	77	335	63.9
1.75	54	25	15	56	5.1	71	145	204	68	345	53.9
1.45	41	23	13	44	4.7	71	130	171	77	346	56.4
1.37	40	29	14	46	4.8	67	132	145	83	352	51.9
1.06	41	33	13	44	4.6	71	124	169	80	346	50.2
0.99	51	20	12	37	4.1	62	107	117	87	370	45.0
0.97	51	27	14	43	4.9	66	111	144	85	368	45.5
1.18	84	5.8	6.8	31	2.9	42	54	47	91	399	33.9
0.45	83	3.7	6.8	22	3.1	36	46	31	89	383	10.6
0.66	64	4.4	8.7	21	3.1	44	52	28	90	384	13.2
0.15	71	4.4	11	20	3.8	38	52	34	102	393	17.6
0.55	72	4.1	10	21	3.1	43	52	29	89	391	15.1
0.37	74	4.4	12	23	3.6	38	51	32	93	381	18.3

TABLE 5 - CONCENTRATIONS OF CONSTITUENTS

Station number[a]	Sample number	Depth in core (cm)	SiO_2 (%)	Al_2O_3 (%)	K_2O (%)	CaO (%)	MgO (%)	Fe_2O_3 (%)	TiO_2 (%)	MnO (%)	P_2O_5 (%)	CO_2 (%)
6	L-6-A	0.0-6.1	82.85	10.58	2.03	0.44	0.28	2.84	0.79	0.04	0.04	
6	L-6-B	6.1-12.2	76.56	11.01	1.90	0.39	0.34	3.18	0.80	0.05	0.05	
6	L-6-C	12.2-18.3	81.03	8.70	1.81	0.51	0.50	2.42	0.83	0.03	0.09	
6	L-6-D	18.3-24.4	84.15	8.56	1.80	0.47	0.31	2.32	0.82	0.04	0.03	
6	L-6-E	24.4-30.5	80.10	8.70	1.78	0.53	0.30	2.13	0.78	0.03	0.08	
6	L-6-F	30.5-36.6	78.92	8.41	1.79	0.44	0.36	2.46	0.78	0.04	0.05	
6	L-6-G	36.6-42.7	79.52	8.33	1.76	0.48	0.55	2.28	0.77	0.04	0.05	
6	L-6-H	42.7-48.8	79.64	8.14	1.76	0.50	0.05	2.41	0.77	0.05	0.04	
6	L-6-I	48.8-54.9	79.63	8.68	1.81	0.63	0.25	2.42	0.77	0.05	0.09	
5	L-5-A	0.0-6.1	65.92	15.57	2.00	0.43	1.23	6.71	0.88	0.10	0.22	
5	L-5-B	6.1-12.2	68.03	15.84	2.10	0.44	0.99	6.28	0.85	0.10	0.24	
5	L-5-C	12.2-18.3	70.38	13.79	2.09	0.39	0.78	5.57	0.82	0.09	0.16	
5	L-5-D	18.3-24.4	67.72	13.14	2.03	0.34	0.97	5.59	0.82	0.08	0.22	
5	L-5-E	24.4-30.5	69.10	13.93	2.08	0.35	0.93	5.47	0.86	0.08	0.19	
5	L-5-F	30.5-36.6	67.79	14.14	2.05	0.39	1.04	5.41	0.84	0.09	0.20	
5	L-5-G	36.6-42.7	69.35	14.67	2.04	0.36	0.76	5.74	0.84	0.09	0.16	0.17
5	L-5-H	42.7-48.8	81.02	11.12	1.96	0.40	0.30	3.85	0.83	0.07	0.11	
5	L-5-I	48.8-54.9	83.23	10.60	1.92	0.40	0.27	3.11	0.81	0.05	0.09	
5	L-5-J	54.9-61.0	80.84	9.52	1.93	0.41	0.53	2.83	0.82	0.05	0.05	
7	L-7-A	0.0-6.1	80.15	8.87	1.69	0.34	0.31	2.29	0.80	0.05	0.07	
7	L-7-B	6.1-12.2	77.33	9.96	1.83	0.22	0.30	2.90	0.78	0.05	0.16	
7	L-7-C	12.2-18.3	77.59	10.17	1.73	0.30	0.36	3.17	0.71	0.05	0.14	
7	L-7-D	18.3-24.4	79.49	10.45	1.91	0.33	0.44	3.72	0.81	0.07	0.15	
7	L-7-E	24.4-30.5	76.34	10.44	1.88	0.27	0.37	3.82	0.79	0.06	0.21	
7	L-7-F	30.5-36.6	79.29	10.69	1.80	0.37	0.58	4.06	0.82	0.05	0.21	
4	L-4-A	0.0-1.5	86.01	6.30	1.20	0.34	0.19	2.33	0.65	0.04	0.08	0.17
4	L-4-B	1.5-7.6	85.06	7.32	1.39	0.30	0.17	2.34	0.71	0.03	0.04	0.14
4	L-4-C	7.6-13.7	84.33	8.12	1.51	0.30	0.39	2.51	0.81	0.04	0.02	
4	L-4-D	13.7-19.8	79.53	10.74	1.44	0.31	0.30	3.78	0.79	0.04	0.13	
4	L-4-E	19.8-25.9	74.93	12.36	1.65	0.33	0.53	4.61	0.80	0.07	0.09	
4	L-4-F	25.9-32.0	74.89	13.23	1.63	0.33	0.68	4.97	0.84	0.08	0.09	
3	L-3-A	0.0-3.0	83.90	9.21	1.84	0.35	0.07	2.44	0.84	0.04	0.09	
3	L-3-B	3.0-9.1	81.05	11.23	1.92	0.30	0.30	3.24	0.91	0.05	0.04	0.17
3	L-3-C	9.1-15.2	79.85	11.65	1.94	0.28	0.13	3.83	0.80	0.06	0.10	0.13
3	L-3-D	15.2-21.3	77.54	11.92	1.86	0.30	0.57	3.79	0.78	0.06	0.09	
3	L-3-E	21.3-27.4	76.09	13.10	1.81	0.32	0.74	4.18	0.76	0.07	0.09	
3	L-3-F	27.4-33.5	74.40	13.53	1.88	0.36	0.61	5.04	0.76	0.08	0.13	
3	L-3-G	33.5-39.6	75.01	12.02	1.90	0.50	0.65	4.53	0.86	0.07	0.12	
1	L-1-A	0.0-6.1	85.43	10.61	1.77	0.54	0.39	2.92	0.74	0.07	0.02	
1	L-1-B	6.1-12.2	83.99	10.03	1.68	0.45	0.22	3.08	0.74	0.05	0.04	
1	L-1-C	12.2-18.3	82.28	10.64	1.80	0.63	0.52	3.96	0.82	0.07	0.11	
1	L-1-D	18.3-24.4	79.46	12.02	2.00	0.73	0.71	4.16	0.79	0.06	0.11	
1	L-1-E	24.4-30.5	74.83	11.70	1.97	0.76	0.80	4.08	0.77	0.07	0.07	
1	L-1-F	30.5-36.6	74.56	11.98	1.94	0.82	0.84	3.77	0.75	0.07	0.10	
1	L-1-G	36.6-42.8	77.83	12.26	2.03	0.88	0.67	4.10	0.76	0.06	0.14	0.07
2	L-2-A	0.0-1.5	79.47	11.61	1.82	0.44	0.41	3.64	0.77	0.07	0.10	
2	L-2-B	1.5-7.6	78.64	9.68	1.70	0.37	0.31	3.30	0.76	0.06	0.08	0.18
2	L-2-C	7.6-13.7	79.64	9.23	1.73	0.34	0.12	3.40	0.74	0.05	0.03	
2	L-2-D	13.7-19.8	79.13	9.73	1.60	0.29	0.28	3.71	0.65	0.06	0.04	
2	L-2-E	19.8-25.9	82.93	8.56	1.61	0.28	0.21	3.32	0.74	0.06	0.04	

---

[a] Listed in upstream to downstream order.

IN CORES FROM LITTLE GRASSY LAKE

Total carbon (%)	B (ppm)	Cu (ppm)	Co (ppm)	Ni (ppm)	Be (ppm)	Cr (ppm)	V (ppm)	Zn (ppm)	Sr (ppm)	Zr (ppm)	<2 µm clay (%)
0.76	97	10	8.7	24	2.9	49	65	55	122	373	27.2
0.91	94	13	12	29	3.5	62	72	66	129	383	31.3
0.59	112	7.8	7.8	22	2.8	52	60	46	118	394	13.3
0.66	92	7.7	7.6	20	2.2	39	62	62	98	366	15.5
0.43	86	7.7	7.6	19	1.9	50	62	52	105	351	9.5
0.43	96	7.6	8.3	20	1.8	42	62	56	105	359	11.8
0.30	104	7.1	7.0	19	1.7	42	60	61	100	352	9.3
0.43	91	7.0	7.5	19	1.9	39	68	55	115	377	9.7
0.49	86	8.8	7.7	20	1.7	42	69	65	109	350	14.8
1.67	71	32	18	40	5.7	64	91	172	79	302	37.7
1.50	74	28	17	43	4.9	58	79	160	85	316	46.5
1.63	72	27	19	42	5.0	64	86	140	95	324	29.3
1.45	76	25	19	41	4.8	64	93	125	89	310	34.0
1.52	86	28	19	42	5.1	63	77	148	90	322	38.4
1.48	75	18	14	42	3.9	60	112	128	96	389	46.0
1.65	71	20	16	39	4.6	58	92	163	90	368	46.6
1.24	84	11	12	29	2.9	55	83	70	110	409	26.5
0.96	112	9.9	10	27	3.1	53	64	58	99	390	17.6
0.95	98	10	9.6	24	2.7	54	61	51	102	400	13.9
0.60	96	8.1	12	24	1.8	42	59	82	85	369	18.2
0.36	106	9.4	12	29	2.1	49	78	93	83	372	18.9
0.36	80	12	12	32	1.4	59	77	95	87	373	18.7
0.23	78	12	12	38	1.6	48	86	95	75	374	22.5
0.26	74	11	11	26	1.7	52	83	106	84	369	16.8
0.17	82	10	11	22	1.7	49	89	87	90	361	10.4
1.03	95	8.4	8.8	18	1.6	31	23	54	52	309	13.5
0.84	103	9.5	10	18	1.7	42	30	55	74	330	15.0
0.57	88	14	14	22	2.5	38	33	59	73	341	19.0
0.67	79	17	12	28	3.3	46	61	61	68	356	
0.27	61	21	9.6	35	3.3	69	76	68	67	337	32.2
0.56	65	21	8.0	34	3.0	52	73	74	66	319	34.2
0.01	99	9.6	12	22	1.8	51	52	55	86	364	12.1
0.60	83	11	10	22	1.8	51	60	62	91	370	22.8
0.58	84	13	14	27	2.9	58	83	86	74	347	29.6
0.51	92	14	13	29	3.3	51	83	90	76	369	25.6
0.42	78	15	16	28	2.1	52	78	95	93	364	30.9
0.58	78	16	15	28	2.3	48	80	80	93	355	30.6
0.31	77	16	9.7	28	1.8	50	78	75	89	359	28.0
1.07	72	8.6	5.8	20	1.5	51	62	54	103	364	16.1
0.74	82	7.8	5.3	19	1.4	56	54	53	112	367	12.1
0.50	68	11	4.7	20	1.6	48	72	54	123	376	10.6
0.23	53	12	3.5	25	1.6	55	83	54	172	364	18.2
0.20	54	23	5.8	33	2.1	52	81	58	156	358	16.7
0.24	55	15	4.6	28	2.1	46	78	55	168	351	16.0
0.05	58	14	5.8	25	2.8	44	76	52	179	367	17.6
0.71	66	12	7.8	24	2.3	46	80	60	103	356	21.2
0.32	72	12	8.0	27	2.1	33	54	67	72	348	19.2
0.07	70	12	8.7	26	1.7	43	51	56	77	328	17.4
0.33	66	13	11	34	2.2	44	60	61	55	330	13.7
0.03	81	11	11	30	1.9	36	47	58	60	323	10.6

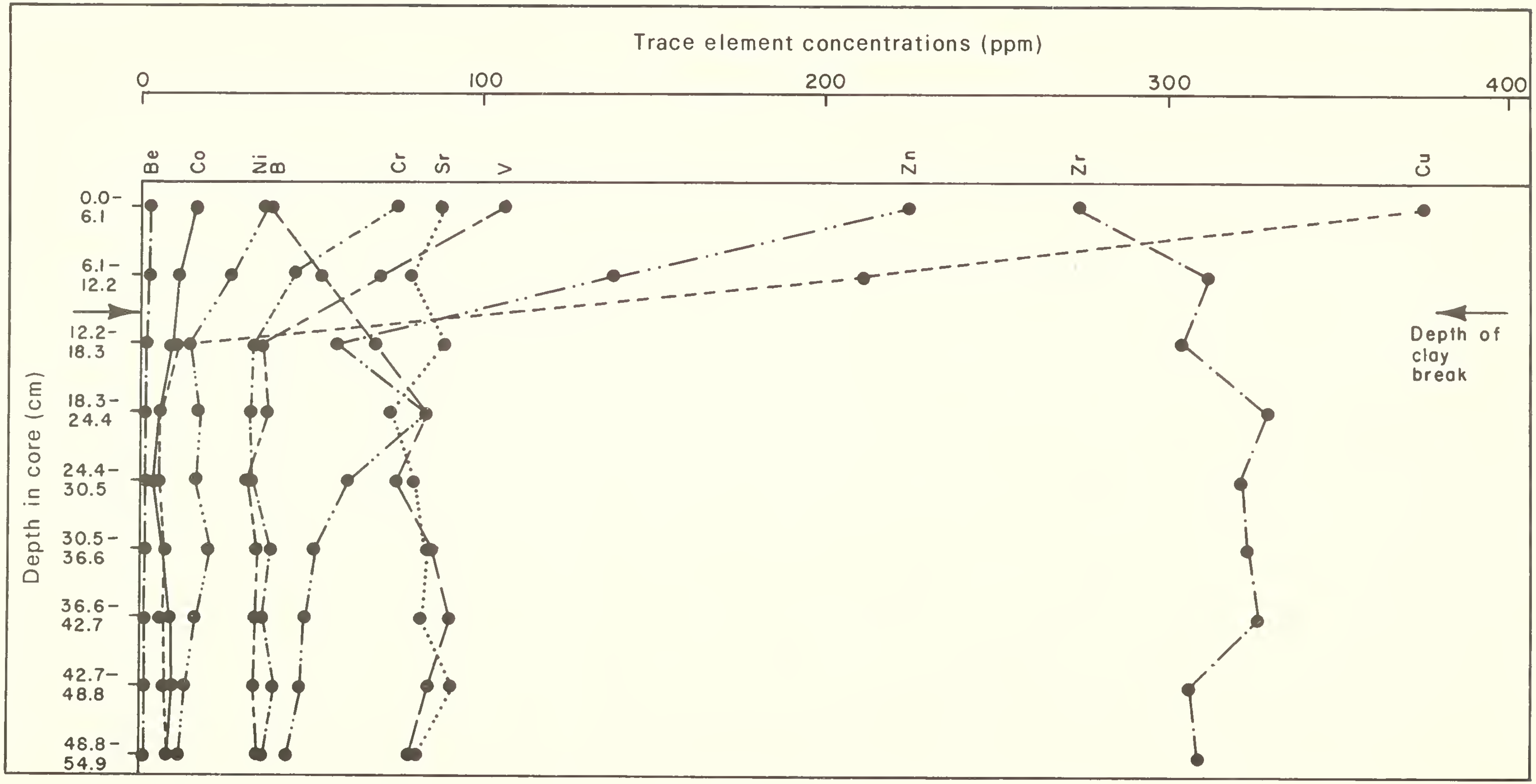

Trace element concentrations (ppm)
0
100
200
300
400
Be
Co
Ni
B
Cr
Sr
V
Zn
Zr
Cu
Depth in core (cm)
0.0-6.1
6.1-12.2
12.2-18.3
18.3-24.4
24.4-30.5
30.5-36.6
36.6-42.7
42.7-48.8
48.8-54.9
Depth of clay break

Fig. 4A

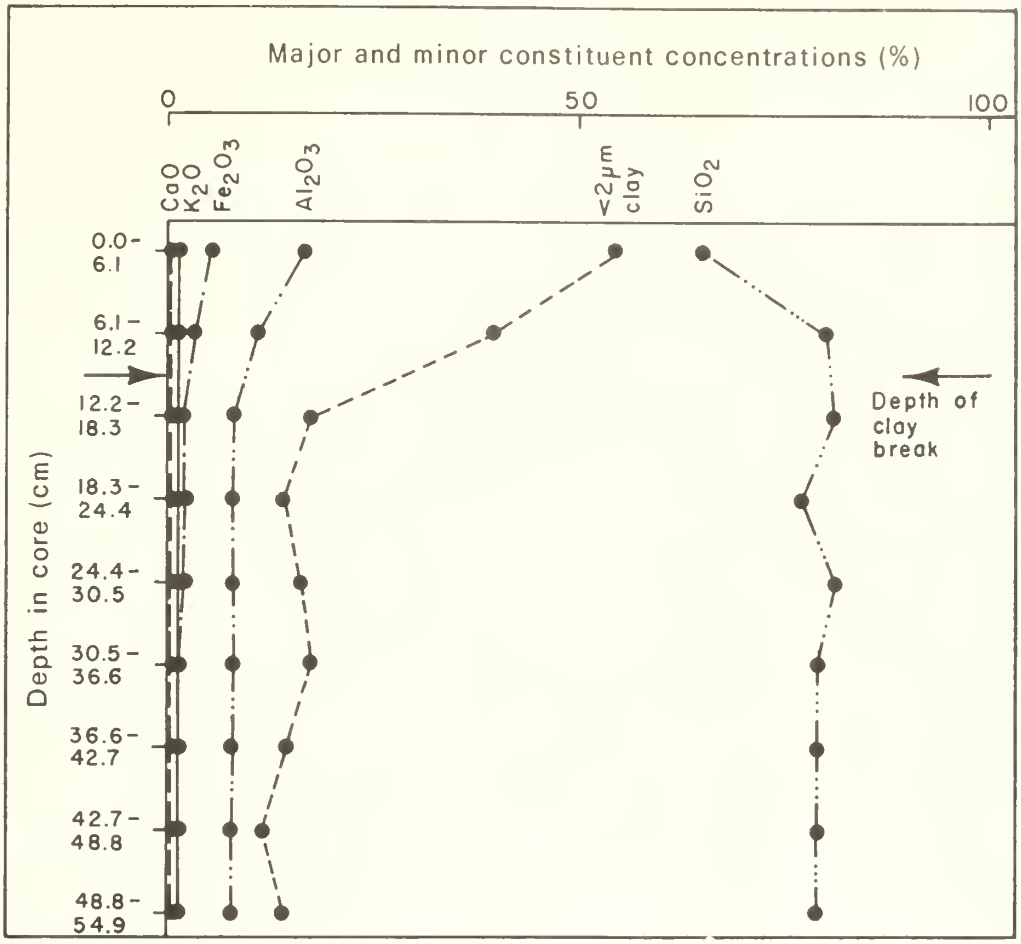


Fig. 4B

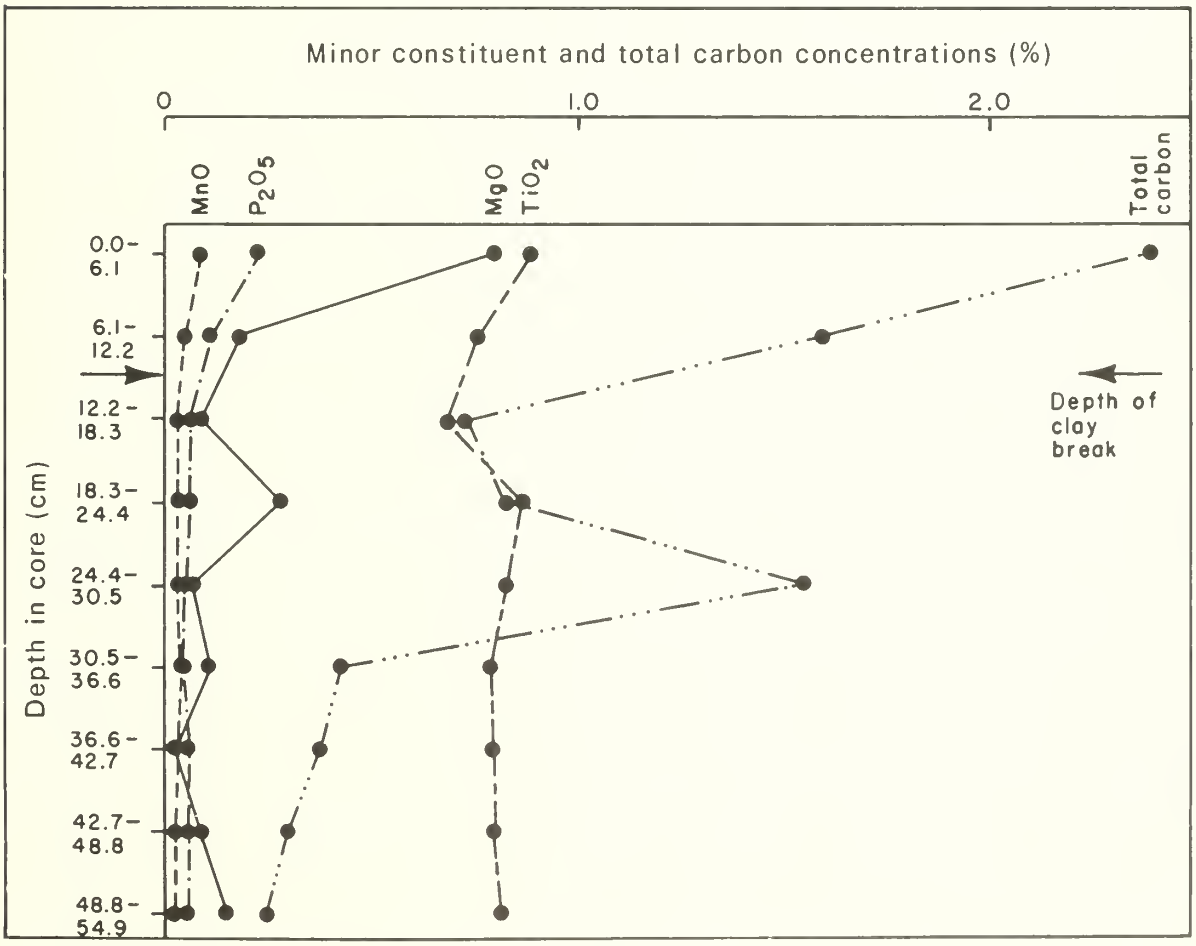


Fig. 4C

Fig. 4A to C - Vertical distributions of major, minor, and trace elements in core 17 of Lake Du Quoin.

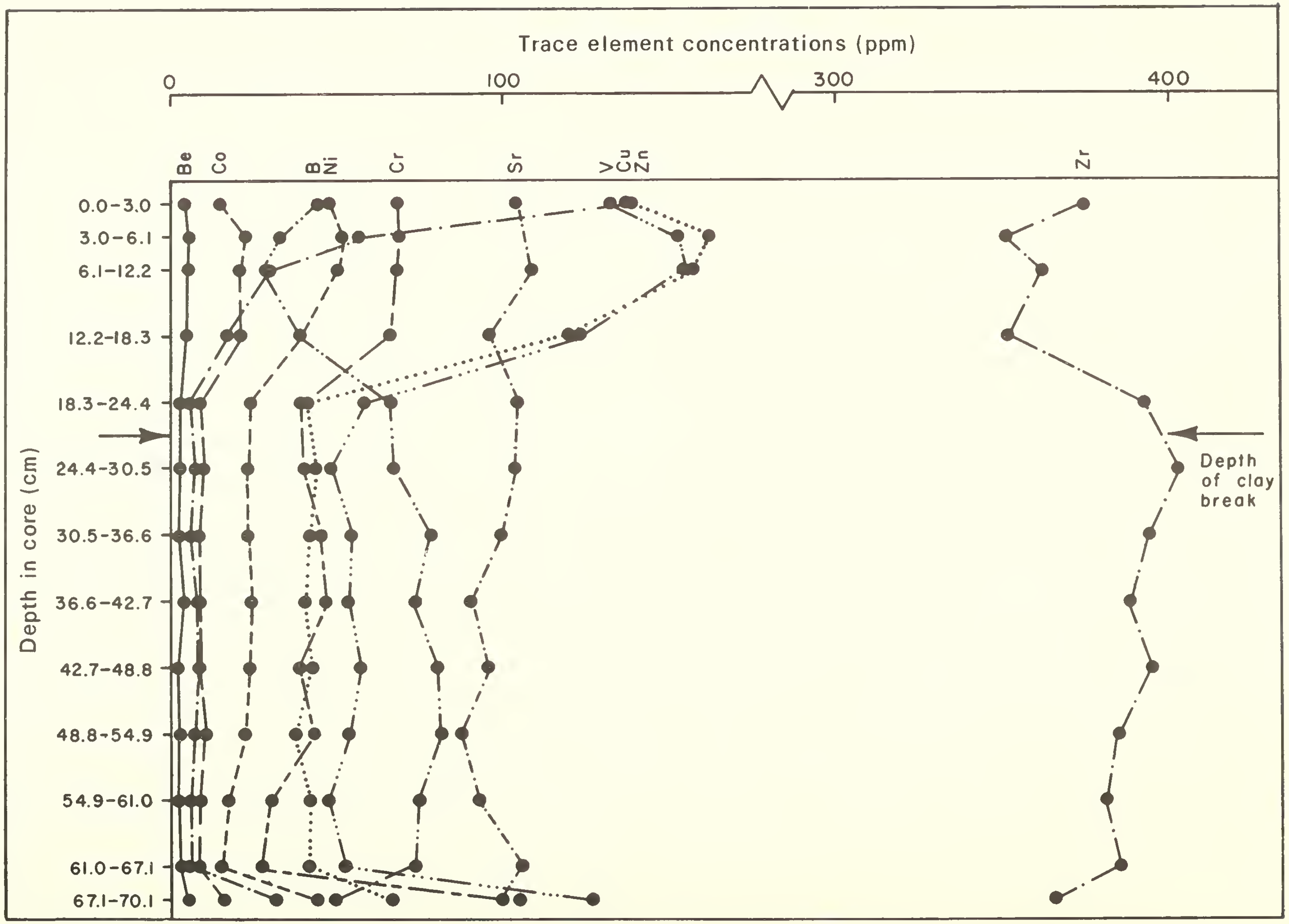


Fig. 5A

Fig. 5A to C - Vertical distributions of major, minor, and trace elements in core 4 of Johnston City Lake.

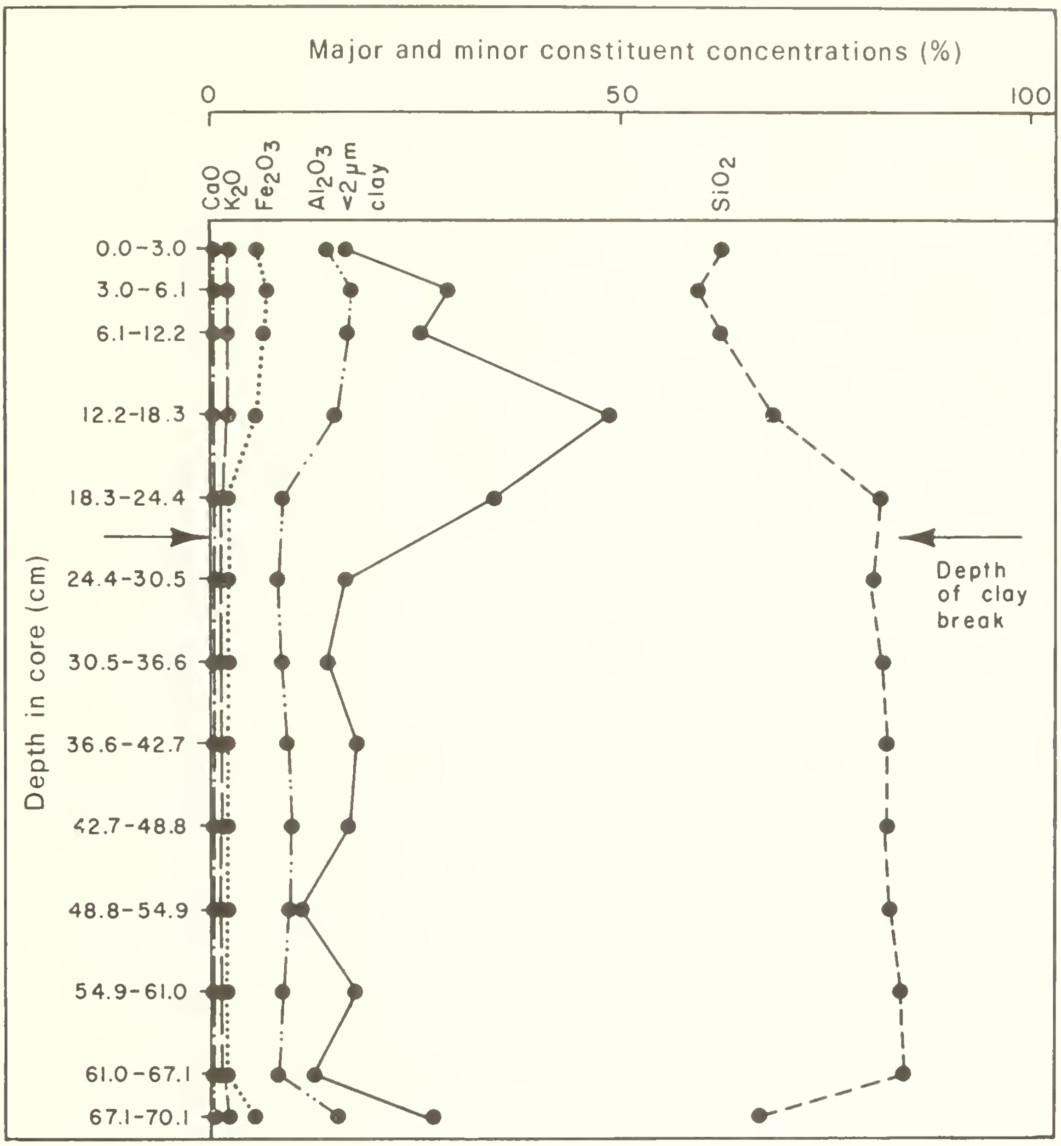


Fig. 5B

The cleared land area is mainly cultivated or in pasturage, with a few small orchards, except for a coal strip mine lying partially in the watershed area. Little Grassy Lake, located in the Crab Orchard National Wildlife Refuge in Williamson County, is presently surrounded by permanent woodland vegetation. There is a small amount of cultivated land in the 15.1 square mile watershed area (Stall et al., 1954). The watershed terrain of the first two lakes is gently sloping; that of Little Grassy Lake has a much higher relief.

To illustrate the extent of sedimentation, in 1957 a party from the Illinois State Water Survey collected sediment cores from the north end of Lake Du Quoin, near the mouth of Reese Creek, the main perennial source of water. In 1972 the lake had filled in enough at the north end so that cores could not be taken in this area. Figure 1 shows the extent of sedimentation as derived from aerial photographs taken in 1951 and 1965. At Johnston City Lake the water was not deep enough to enable taking cores near the mouth of Lake Creek, the main water source, at the southeast end of the lake. The extent of sedimentation, again derived by comparing

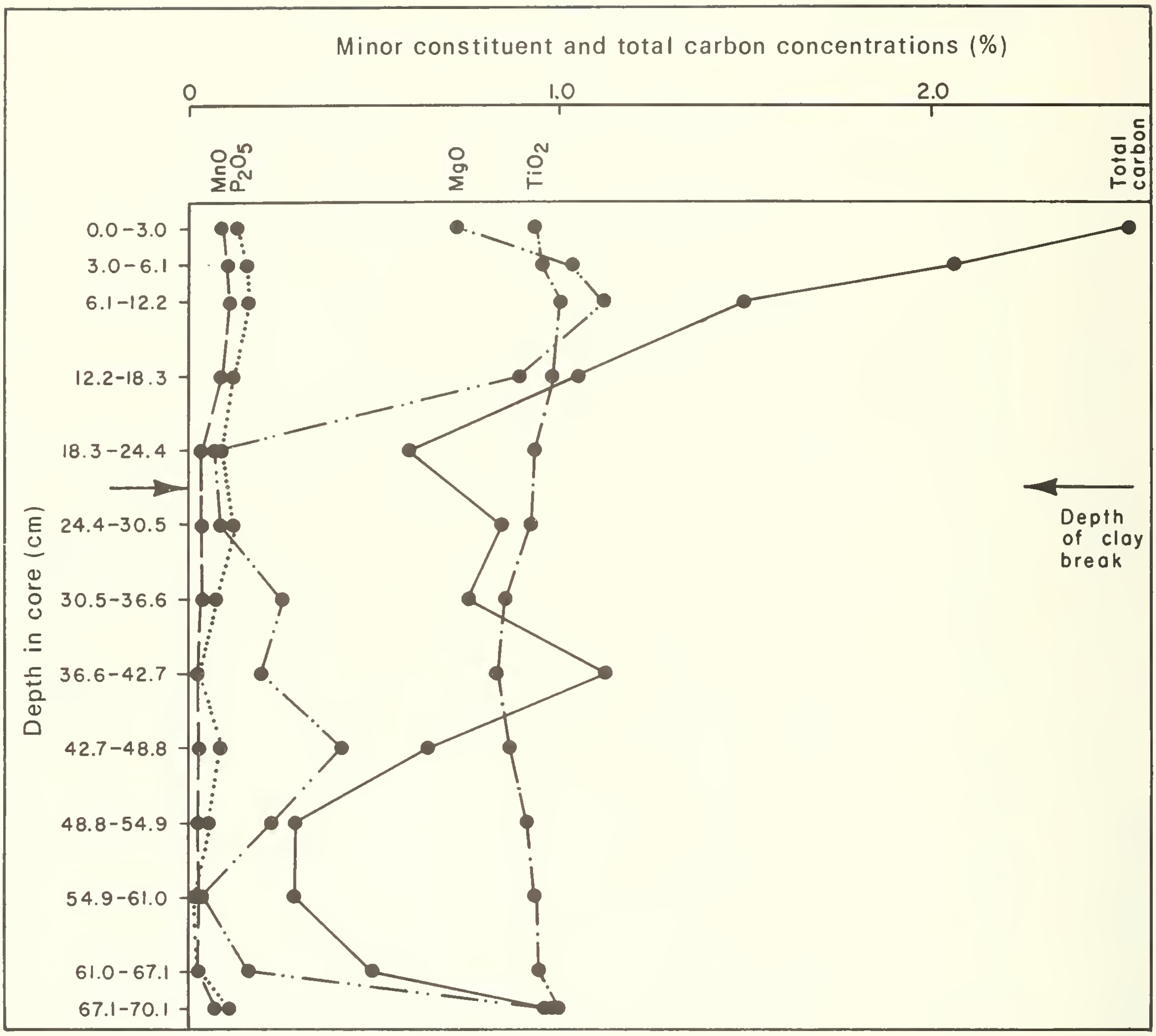


Fig. 5C

aerial photographs from 1951 and 1965, is illustrated in figure 2. As suspended sediment is carried into the lakes by the source streams, the velocity of the water decreases, allowing the coarser material to fall out rapidly. The clay content data show that the fine-grained material is carried further into the lakes. Little Grassy Lake has no distinct upstream-to-downstream trend of clay content, perhaps because this lake has more sediment sources, which would tend to confuse a possible trend. This lake is deeper, the surrounding relief is stronger, and the land in the watershed is mainly forested or grassy.

There are two possible explanations for the existence of the clay breaks in Lake Du Quoin and Johnston City Lake. The first is that the upper portions of the cores are lacustrine sediment and the lower portions are original lake bottom. The second possibility is that both portions are lacustrine sediment. The lower portion could be sediment washed into the lakes from rapidly eroding areas, particularly if excavation took place during construction of the lakes and vegetation on the surrounding dry area was destroyed.

In order to determine if there are general relationships between separate sediment constituents, correlation coefficients for the upper and lower portions of the cores from Lake Du Quoin and Johnston City Lake and for the entire cores of Little Grassy Lake were calculated by computer for 22 matrix elements. The correlation matrix included the 10 major and minor constituents, 10 trace elements, depth in the core, and the clay content. The results are summarized in table 6. In each separate group of constituents each member showed a correlation to every other member of the group. For example, in the Little Grassy Lake data, fourth and fifth rows, the correlations appear identical except for the inclusion of MnO and Be in row four and P_2O_5 in row five. MnO and Be are not included in row five because their correlation with MnO did not meet the arbitrary criterion. The criterion used to show correlation, either positive or negative, was that the correlation coefficient have a magnitude of 0.65 or greater. As might be expected, the clay mineral components, Al_2O_3, Fe_2O_3, MnO, etc., correlated well with each other in all cases. The clay content, however, did not correlate well with the clay mineral components in either the upper or lower sediment portions from Johnston City Lake. Sediments from only Little Grassy Lake showed a good correlation between CaO and Sr.

Factor analysis, a statistical treatment of data to show the main factors which differentiate the samples from one another, was performed by computer for each of the three lakes. In each case, the most important factor included knowledge of the clay components, Al_2O_3, Fe_2O_3, MgO, MnO, P_2O_5; the trace elements Ni, V, and Zn; and the clay content. Factor analysis indicates that a large majority of the samples from each of the lakes may be differentiated on the basis of the clay mineral component concentrations and the clay content.

Subsequent to the factor analysis, a cluster analysis, based on squared Euclidean distances, was calculated by computer. This cluster analysis classified samples into groups of close similarity, which were produced as a dendogram, a diagram showing that the samples are clustered into two major groups with five subgroups. A simplified version of the dendogram is shown in figure 7. The two major groups contain the samples from the lower portions of the cores in one group and those from the upper portions in the second group. The first major group was divided into three subgroups, containing almost all of the lower portion samples from Johnston City Lake in one subgroup, most of the lower portion samples from Lake Du Quoin in the second subgroup, and most of the samples from the entire cores from Little Grassy Lake in the third subgroup. Likewise, the second major group has two subgroups, the first containing most of the upper core portion samples from Johnston City Lake and the second containing almost all the upper portion samples from Lake Du Quoin. Core 5 from Little Grassy Lake was classified with samples from the upper portions of Johnston City Lake. An examination of the clay component data from this core in table 5 with that for the clay component data for Johnston City Lake in table 4 reveals the similarities between the data.

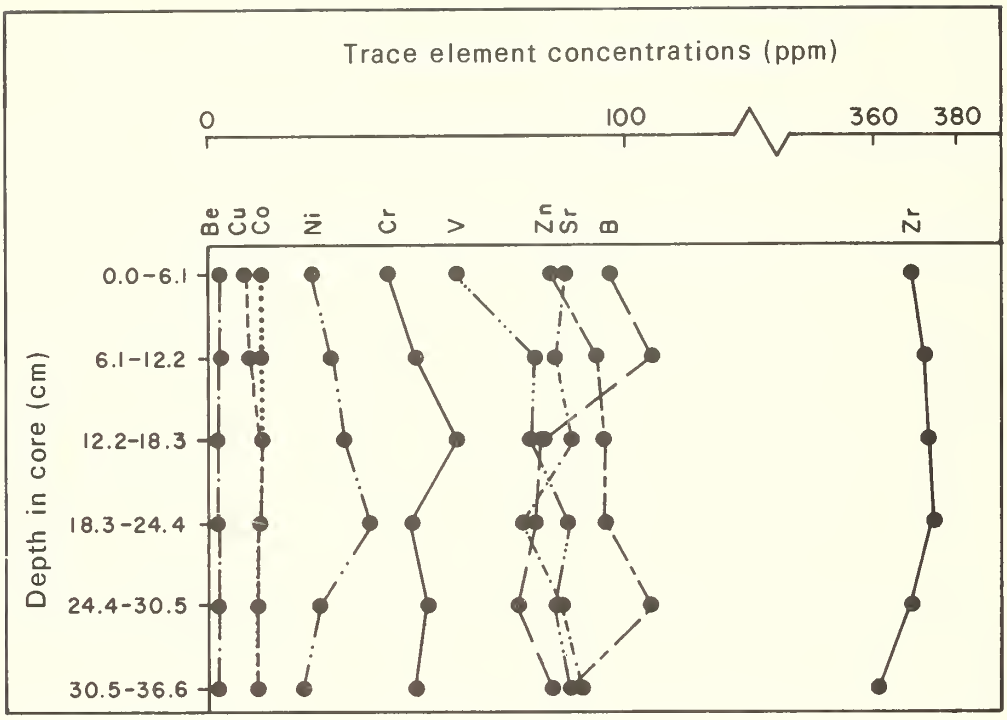

Trace element concentrations (ppm)
0
100
360
380
Be
Cu
Co
Ni
Cr
V
Zn
Sr
B
Zr
Depth in core (cm)
0.0-6.1
6.1-12.2
12.2-18.3
18.3-24.4
24.4-30.5
30.5-36.6

Fig. 6A

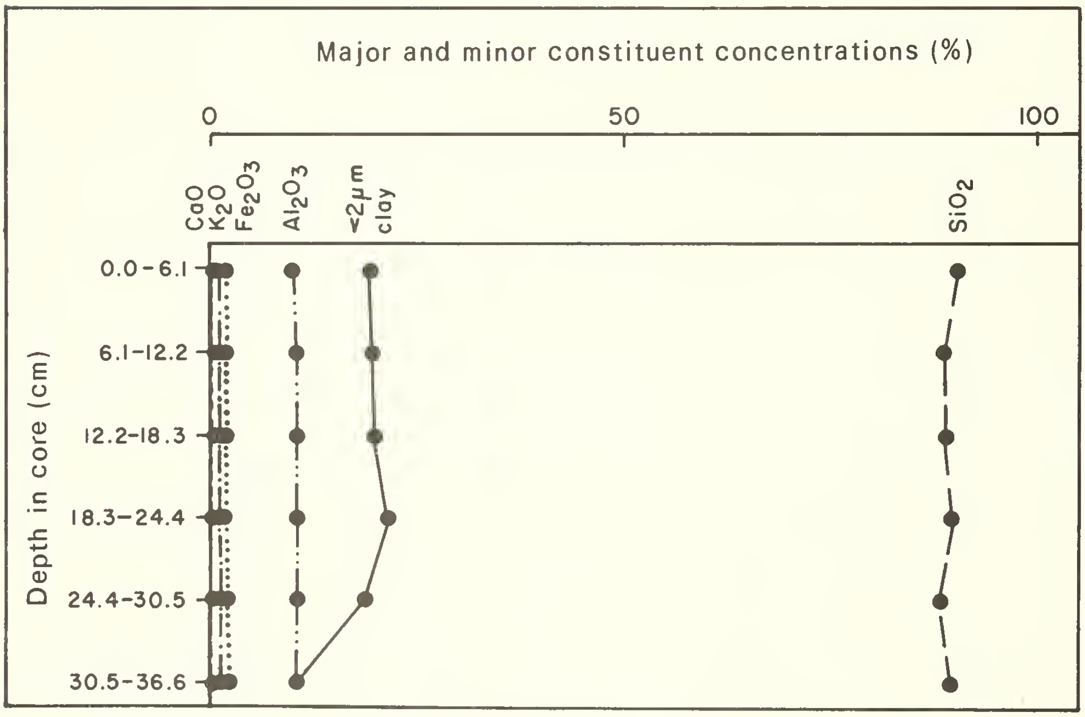

Major and minor constituent concentrations (%)
0
50
100
CaO
K_2O
Fe_2O_3
Al_2O_3
<2μm clay
SiO_2
Depth in core (cm)
0.0-6.1
6.1-12.2
12.2-18.3
18.3-24.4
24.4-30.5
30.5-36.6

Fig. 6B

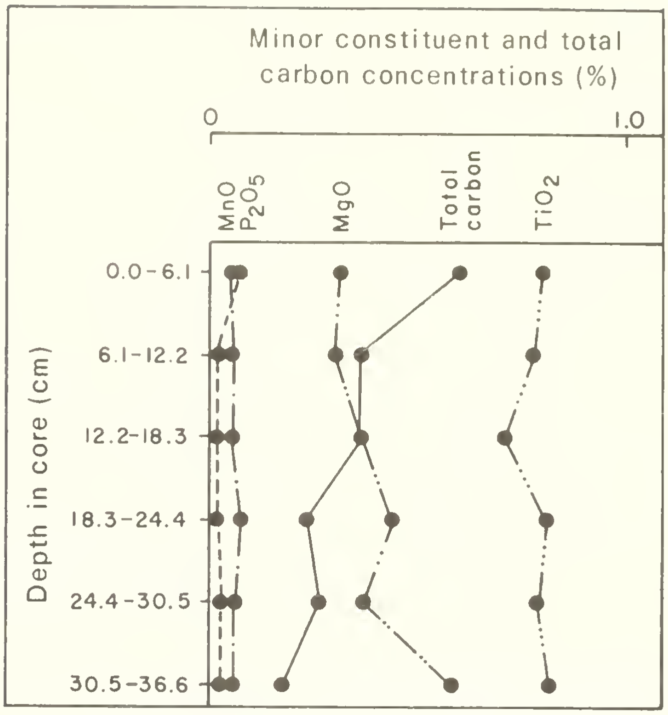


Fig. 6C

Fig. 6A to C - Vertical distributions of major, minor, and trace elements in core 7 of Little Grassy Lake.

The results of these two treatments confirm statistically that the upper core portions are different from the lower core portions and the Little Grassy Lake cores, and give the bases for the differentiations.

The data for copper concentration in tables 3 to 5 indicate that it is higher in the upper portions of the sediments than in the lower portions. But the question remains as to whether the copper concentration is elevated only in proportion to the elevation in clay content, or if another source has contributed.

Copper and alumina showed good correlation with each other throughout the cores from Little Grassy Lake, in the upper portions from Lake Du Quoin, and in the lower portions from Johnston City Lake. The Cu-Al_2O_3 correlation coefficient for the lower sediment portions from Lake Du Quoin is $\sim$0.58, a weak correlation; however, it may be accurate to assume that copper is related to the clay material in these samples. If the Cu-Al_2O_3 relationship is relatively constant in the lower portions of each core, it should be possible to determine whether the copper concentration is elevated above the norm in the upper core portions. That is, the lower core portions should tell the relative amount of copper associated with the clay in the lower portions. If the clay mineral composition is the same in the upper and lower core portions, as the X-ray diffraction data indicates, an elevated Cu/Al_2O_3 ratio in the upper portion of the sediment means that Cu has been contributed to the sediment by some source other than the clay. Calculating the ratios of the concentrations of Cu and Al_2O_3 reveals that the ratios for cores from Lake Du Quoin and Johnston City Lake (table 7), starting at the lowest point

TABLE 6 - SUMMARY OF CORRELATIONS OF SEDIMENT CONSTITUENTS[a]

Little Grassy Lake

Entire Core

<2μ clay, Al_2O_3, Fe_2O_3, MnO, Cu, Ni, Be, Zn, $-SiO_2$[b]
<2μ clay, total carbon, Be, Zn
<2μ clay, Co, Ni, Be, Zn
MgO, Al_2O_3, Fe_2O_3, MnO, Ni, Be, V, Zn, $-SiO_2$
MgO, Al_2O_3, Fe_2O_3, P_2O_5, Ni, V, Zn, $-SiO_2$
MgO, Al_2O_3, Fe_2O_3, MnO, Cu, Ni, Be, Zn, $-SiO_2$
Al_2O_3, K_2O, V
Cr, V
CaO, Sr

Lake Du Quoin

Upper Portions

<2μ clay, Al_2O_3, MgO, Cu, V, -Sr
<2μ clay, Al_2O_3, MgO, Fe_2O_3, Cu, -Sr
<2μ clay, Cu, Be
MnO, Fe_2O_3, Zn, $-SiO_2$, -Sr
MnO, Fe_2O_3, P_2O_5, Zn, -Sr
MgO, Fe_2O_3, -B
MgO, Ni
Al_2O_3, Zn
K_2O, TiO_2
CaO, -sediment depth
CaO, total carbon
Co, -B
Co, Be
Ni, V

Lower Portions

<2μ clay, Al_2O_3
<2μ clay, total carbon, Cu, Zn
<2μ clay, total carbon, Ni, V
<2μ clay, total carbon, Ni, Zn
<2μ clay, total carbon, V, -B
Fe_2O_3, CaO, total carbon, Co
Fe_2O_3, MnO, total carbon
Fe_2O_3, Zn
Fe_2O_3, $-SiO_2$
Fe_2O_3, -B
P_2O_5, total carbon, Ni, Zn
MgO, V
Be, V

TABLE 6 - Continued

Johnston City Lake

Upper Portion

Al_2O_3, Fe_2O_3, MnO, Ni, V, Cr, $-SiO_2$
Fe_2O_3, MnO, Zn
Al_2O_3, Fe_2O_3, MnO, Ni, V, Cr, -B
Al_2O_3, K_2O
CaO, Cu
Ni, Be

Lower Portions

Al_2O_3, Fe_2O_3, Cu, V, Zn, $-SiO_2$
Al_2O_3, Cu, V, Zn, $-SiO_2$
Al_2O_3, Ni, Cr, V
Al_2O_3, Cu, Ni
Al_2O_3, Cr, $-SiO_2$
K_2O, Al_2O_3, Cr, V
K_2O, TiO_2
TiO_2, Zr
Cr, -B
Zr, Sr

---

[a] All items in one row have a correlation coefficient of 0.65 or greater with every other item in the same row (see text, p. 21).

[b] A minus sign before a chemical symbol indicates a negative correlation.

in a core and proceeding upward, are relatively constant to a certain point. Above this point, the Cu/Al_2O_3 ratio increases. In all cases, the point at which the increase begins coincides with, or is just below, the clay break. When the ratio is calculated for Little Grassy Lake cores, however, no such increase occurs.

It is known that copper may precipitate as $CuCO_3$ in fresh water systems (Stiff, 1971) and/or is adsorbed on illite which would subsequently be precipitated (O'Connor and Kester, 1975). Lake Du Quoin was treated with $CuSO_4$ from the time of its construction (1936-1937) to 1971, and for Johnston City Lake treatment was continued from at least as early as 1957, and possibly from its construction time (1921-1922), through the summer of 1971. The elevated Cu/Al_2O_3 ratio indicates that the copper from this treatment precipitated and that the ratio can be used in these and similar cases to differentiate the lacustrine sediment from the original lake bottom, or lower sediment unit.

Similarly, in tables 3 to 5 zinc concentrations are also noted to be elevated in the upper sediment portions from Lake Du Quoin and Johnston City Lake. The ratio of Zn/Al_2O_3 concentrations also indicates a source of zinc other than clay. It is possible that a zinc compound was an impurity in the copper sulfate used to treat the lake waters.

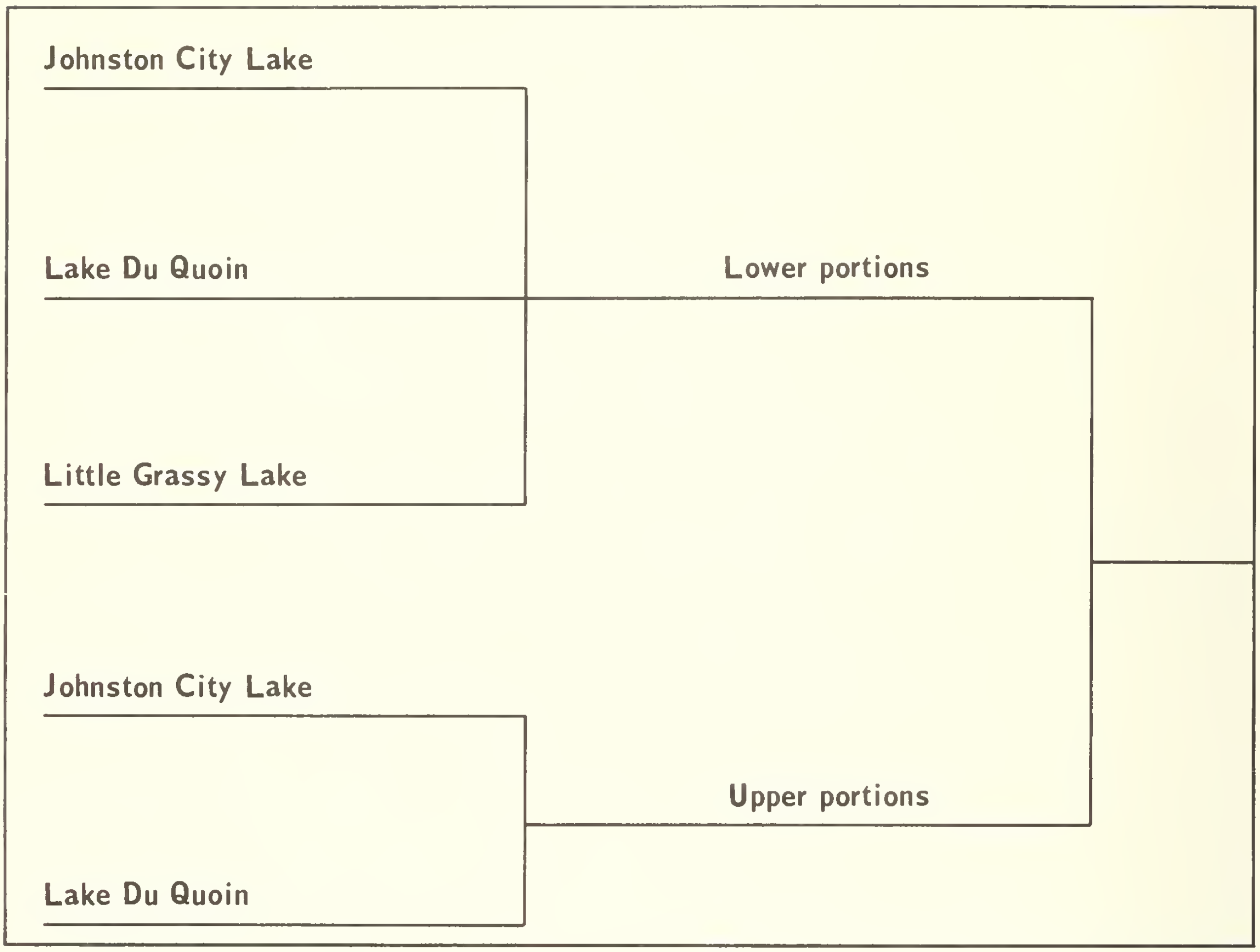


Fig. 7 - Simplified cluster analysis dendogram illustrating statistical classification of samples into groups.

In further characterizing the lake sediments, the areal distributions of the means of each constituent in the upper and lower sediment portions and in the entire cores from Lake Du Quoin and Johnston City Lake and those of the entire cores from Little Grassy Lake were determined by plotting the mean concentrations on maps of the lakes. Maps showing the areal distributions of clay content, Al_2O_3, Cu, and Zn in each lake are shown in figures 8 through 10. The three numbers at each sampling station in figures 8 and 9 indicate the following: the top number is the mean concentration in the upper sediment portion; the second is the mean concentration in the lower sediment portion; and the third is the mean concentration for the entire core.

In Lake Du Quoin the clay content, MgO, CaO, P_2O_5, Cu, and V have generally increasing concentrations from upstream to downstream in the upper sediment portions, but SiO_2 and Sr show the opposite tendency. In the lower sediment portions, SiO_2, Sr, and Zr have generally increasing concentrations downstream, whereas Cu has the opposite trend. The concentrations of K_2O, MnO, and TiO_2 are relatively constant throughout the lake in both sediment portions, and CaO and P_2O_5 have generally constant concentrations in the lower portions. All other constituents have random areal distributions.

TABLE 7 - Cu/Al_2O_3 RATIOS ($X10^4$) FOR LAKE DU QUOIN, JOHNSTON CITY LAKE, AND LITTLE GRASSY LAKE CORES[a]

Lake Du Quoin	Core 1	Core 10	Core 25	Core 17	Core 18
	30.25	$\underline{12.80}$	12.43	$\underline{22.63}$	24.00
	22.25	1.48	19.18	18.56	30.43
	$\underline{8.30}$	1.10	16.99	1.39	27.32
	1.48	0.86	20.13	0.72	$\underline{24.49}$
	1.08	0.79	26.93	0.65	5.76
	1.26	0.94	27.28	0.97	1.24
	1.19		16.84	0.93	1.19
	1.26		21.84	0.99	1.00
	1.35		30.52	1.02	0.90
	1.26		17.56		<0.36
	1.48		$\underline{19.76}$		
			5.47		

Johnston City Lake	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8	Core 9
	12.91	4.09	1.20	9.68	12.70	9.02	2.36	1.79	$\underline{1.31}$
	1.03	2.14	0.79	3.34	6.60	14.84	$\underline{1.71}$	1.95	0.56
	1.44	$\underline{1.87}$	1.14	1.73	1.21	10.27	1.03	$\underline{1.55}$	0.64
	1.33	1.27	0.82	$\underline{1.12}$	1.44	1.51	0.90	0.83	0.74
	1.77	1.15	0.96	0.61	1.55	1.40	0.97	0.77	0.84
	1.93	1.04	0.84	0.95	1.43	1.52	0.75	0.85	0.71
	1.34	0.67	0.79	0.64	$\underline{1.21}$	0.96	0.71	0.78	0.47
	$\underline{1.75}$	0.68	0.80	0.89	1.07		0.69	0.85	0.53
	0.69	0.71	0.80	0.81	0.86		0.74	0.86	
	0.47	0.81		0.81	0.80			0.52	
	0.50	0.67		0.68				0.45	
	0.51	0.70		0.72				0.40	
	0.50	0.74		2.01				0.46	
	0.52								

Little Grassy Lake	Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7
	0.81	1.03	1.04	1.33	2.06	0.95	0.91
	0.78	1.24	0.98	1.30	1.77	1.18	0.94
	1.03	1.30	1.12	1.72	1.96	0.90	1.18
	1.00	1.34	1.17	1.58	1.90	0.90	1.15
	1.97	1.29	1.15	1.70	2.01	0.89	1.05
	1.25		1.18	1.59	1.27	0.90	0.94
	1.14		1.33		1.36	0.85	
					0.99	0.86	
					0.93	1.01	
					1.05		

---

[a] The horizontal line in each column of ratios for Lake Du Quoin and Johnston City Lake indicates the position of the clay break in the core.

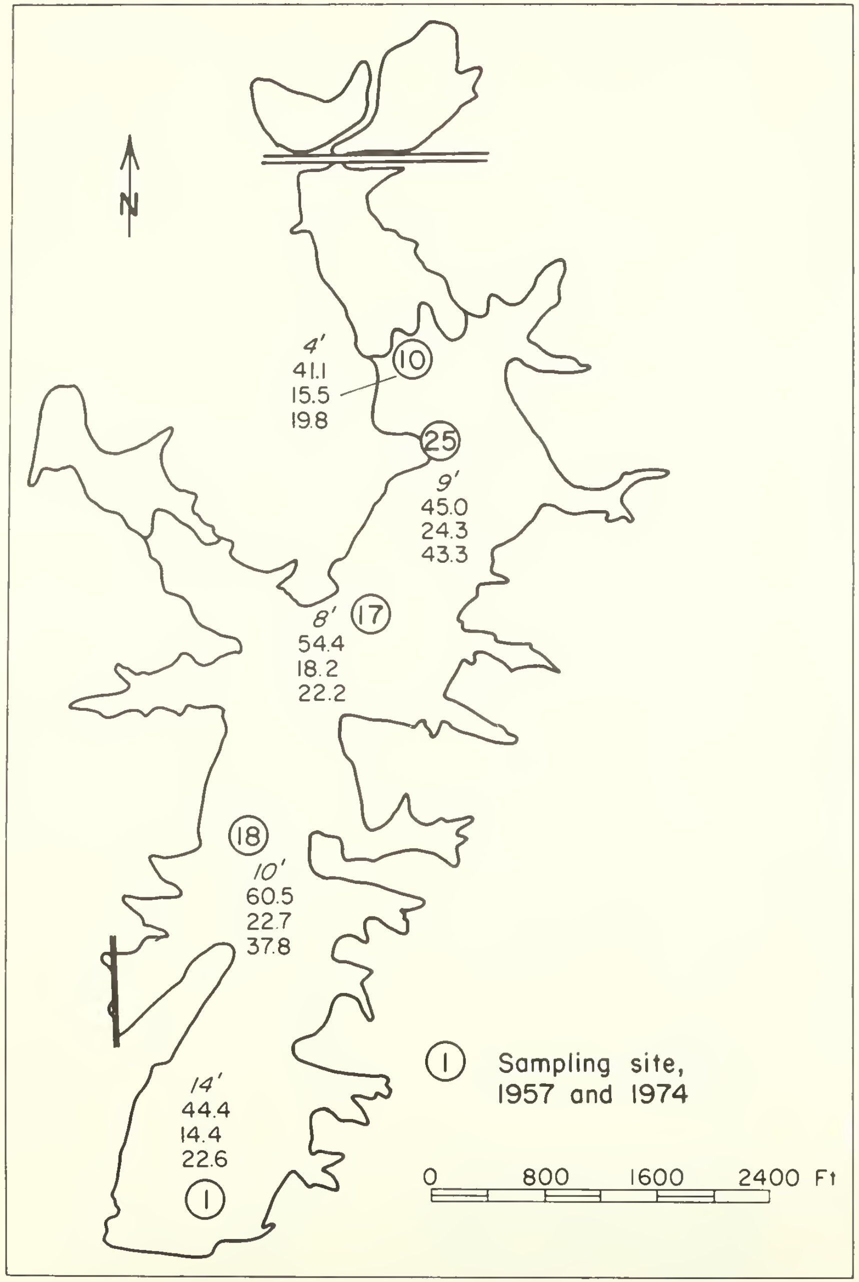


Fig. 8A - <2 μ clay (%) sampled at various sampling sites at depths indicated in italics.

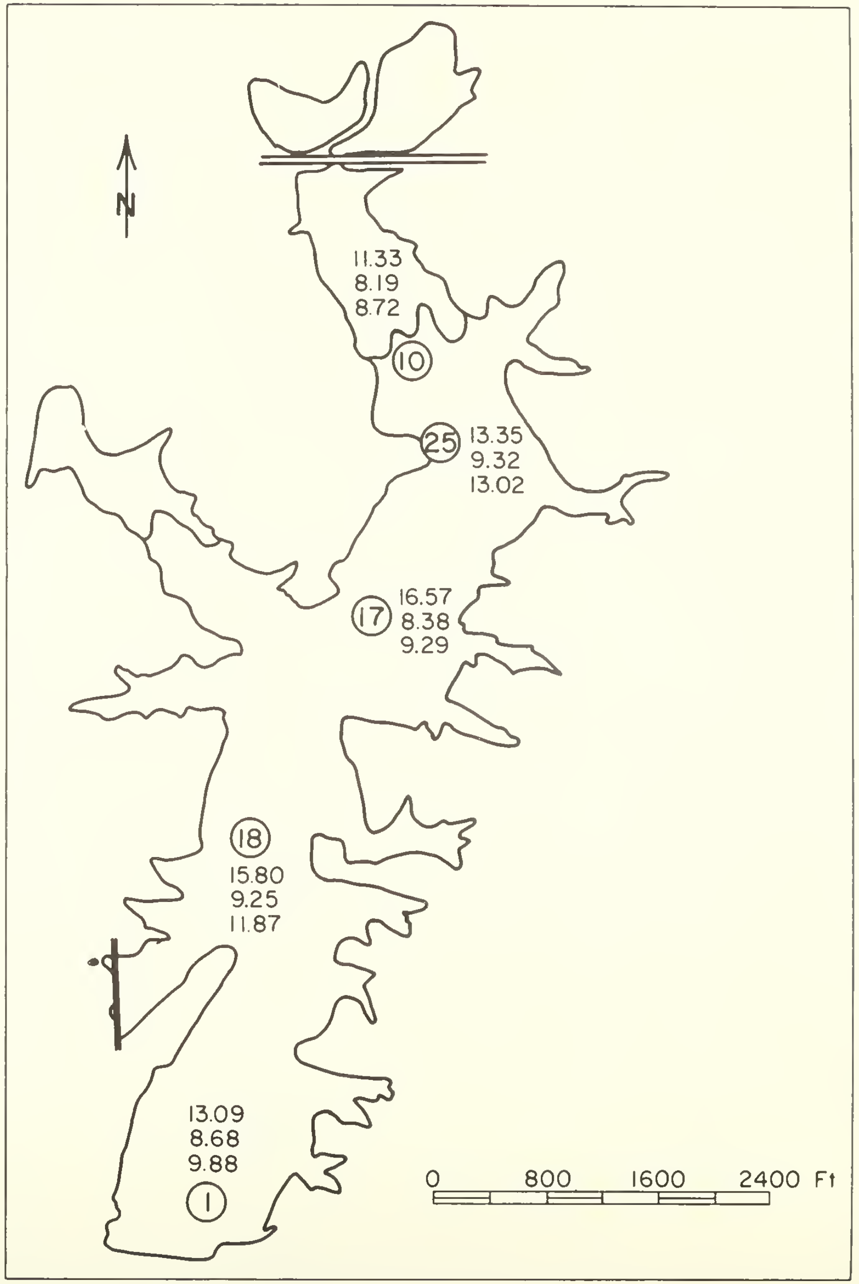


Fig. 8B - Al_2O_3 (%) sampled at various sampling sites.

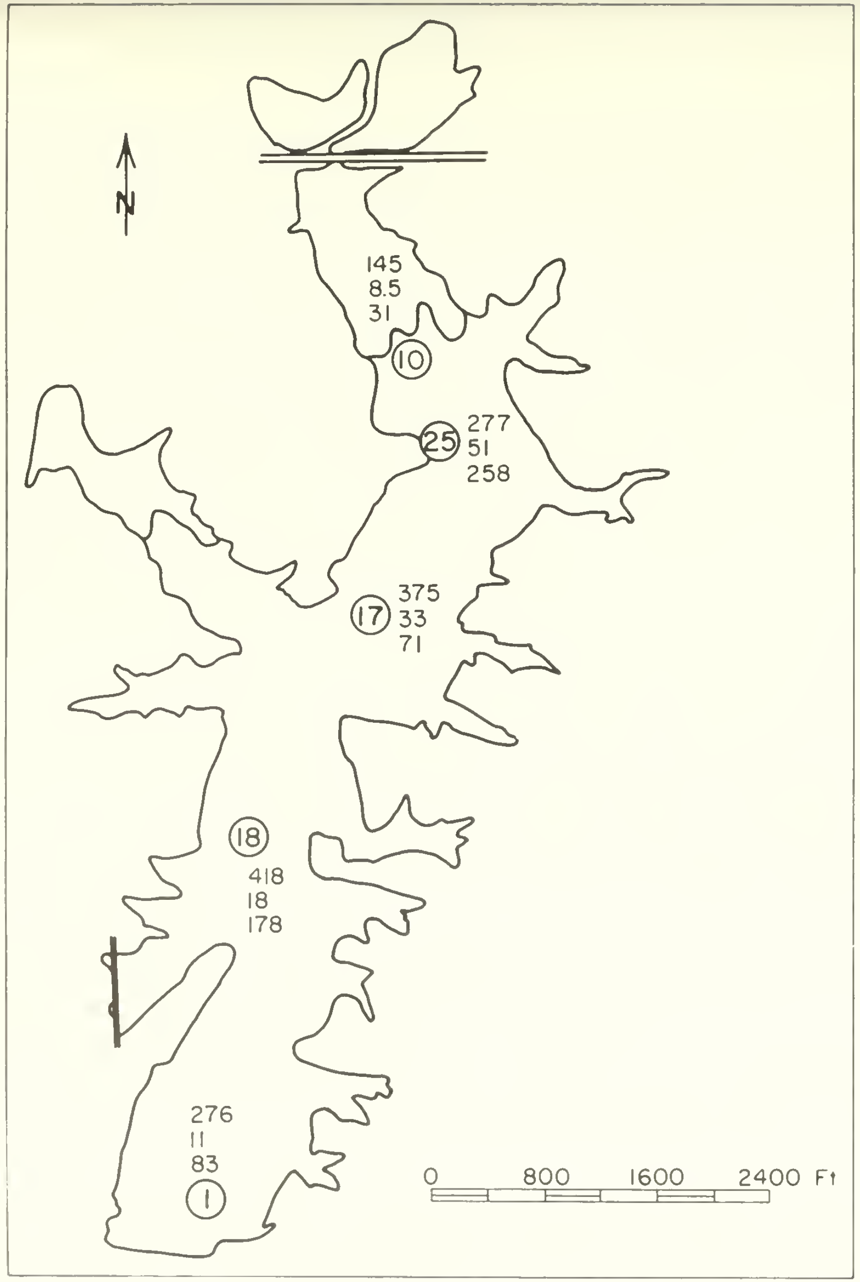


Fig. 8C - Cu (ppm) sampled at various sampling sites.

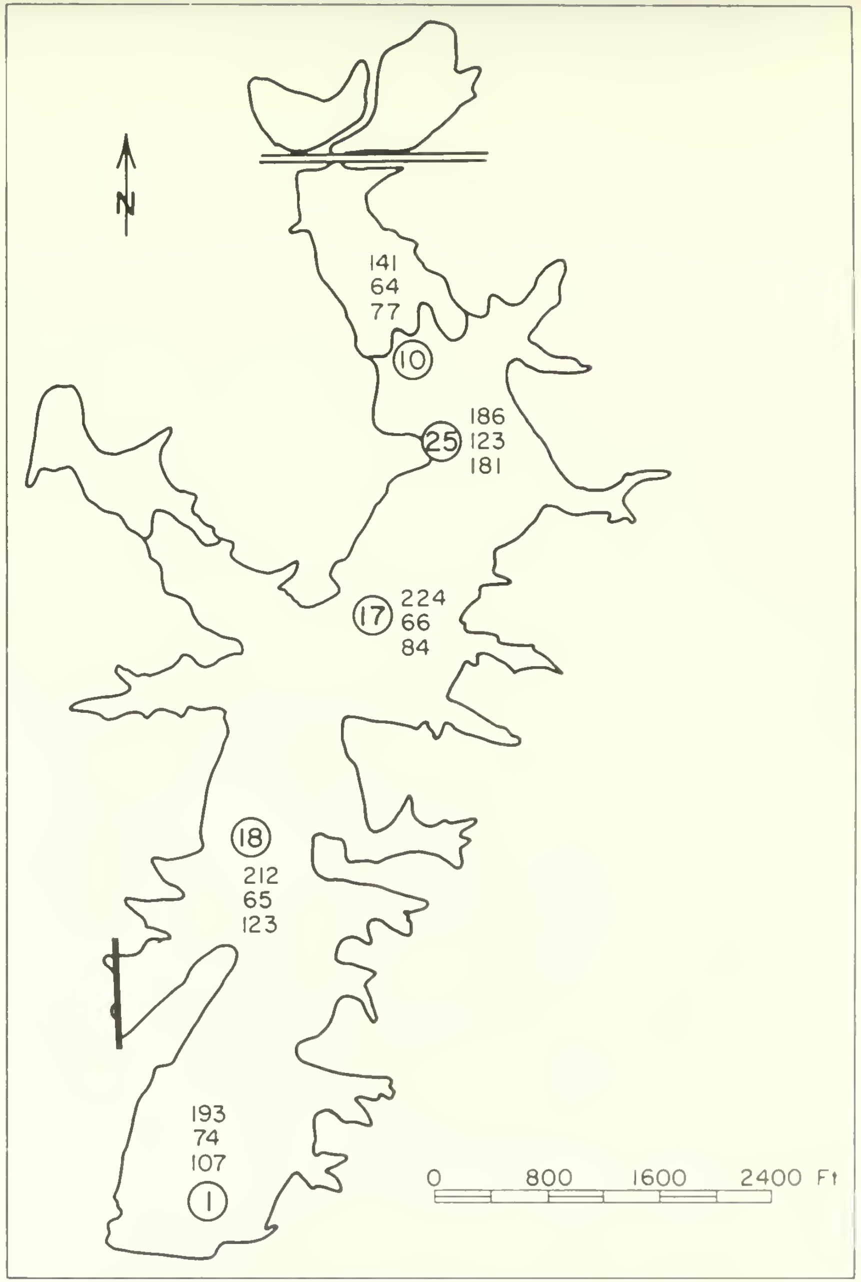


Fig. 8D - Zn (ppm) sampled at various sampling sites.

Fig. 8A to D - Areal distribution in Lake Du Quoin. At the circled sampling sites, the top number is the mean concentration in the upper portion of the core. The second number is the mean concentration in the lower portion, and the third number is the mean concentration in the entire core.

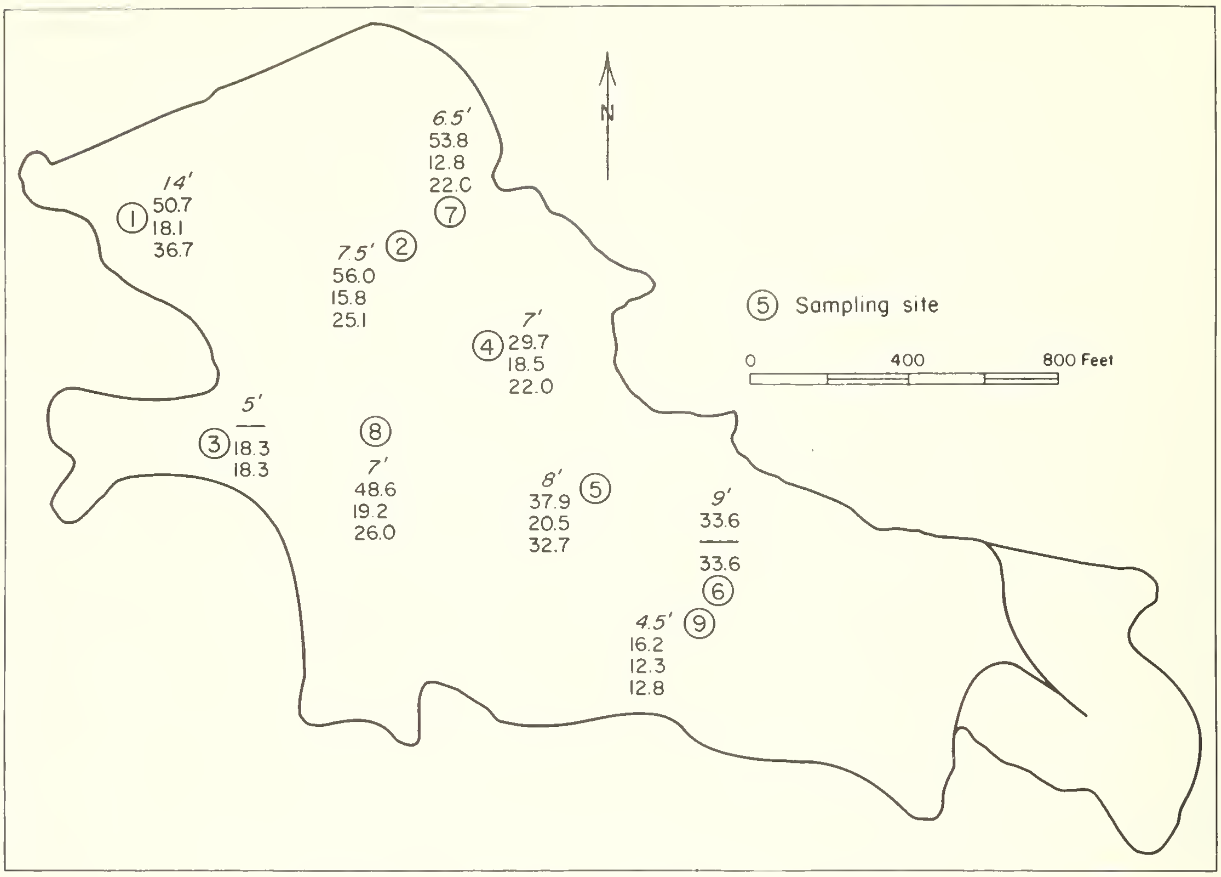


Fig. 9A - <2 μ clay (%) sampled at all sites at water depths indicated in italics.

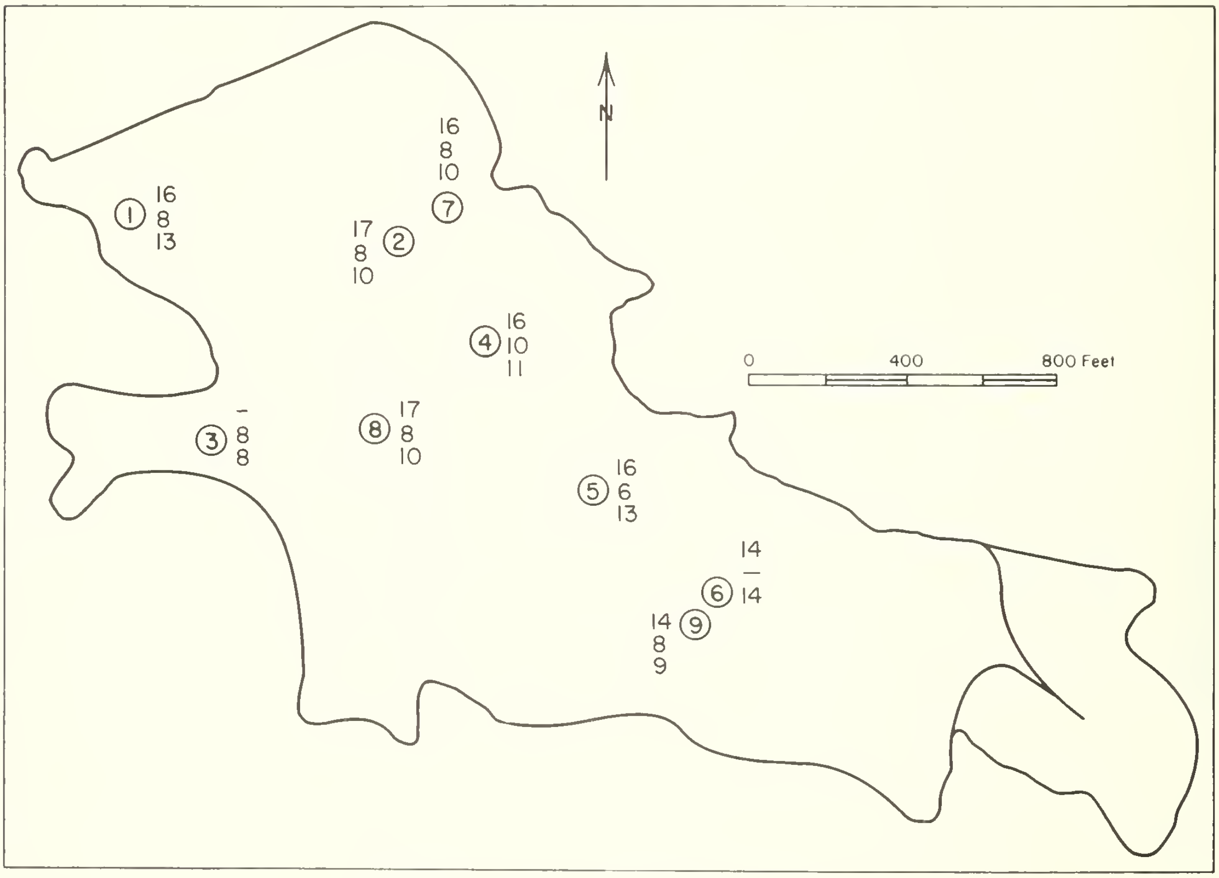


Fig. 9B - Al_2O_3 (%) sampled at all sites.

Fig. 9A to D - Areal distribution in Johnston City Lake. At all sampling sites, the top number is the mean concentration in the upper portion of the core. The second number is the mean concentration in the lower portion, and the third number is the mean concentration in the entire core.

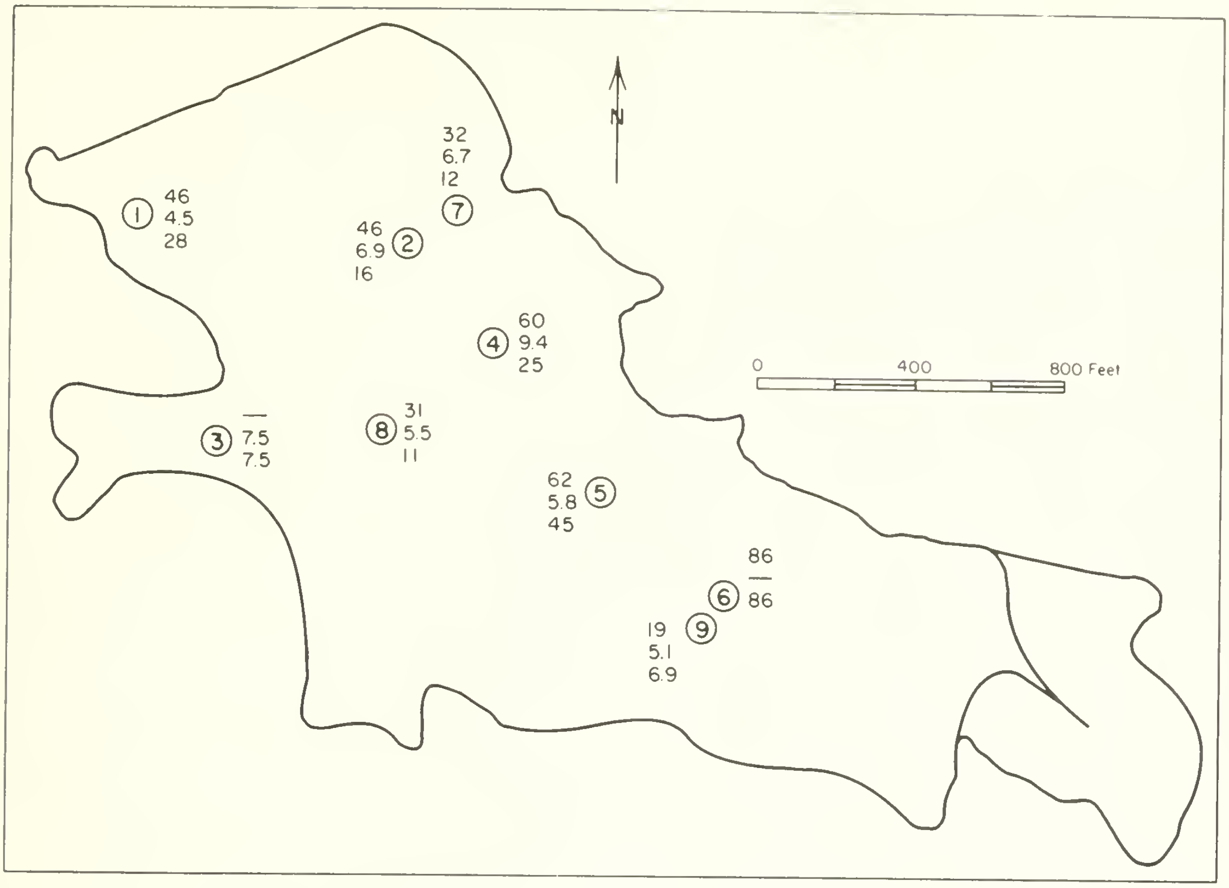


Fig. 9C - Cu (ppm) sampled at all sites.

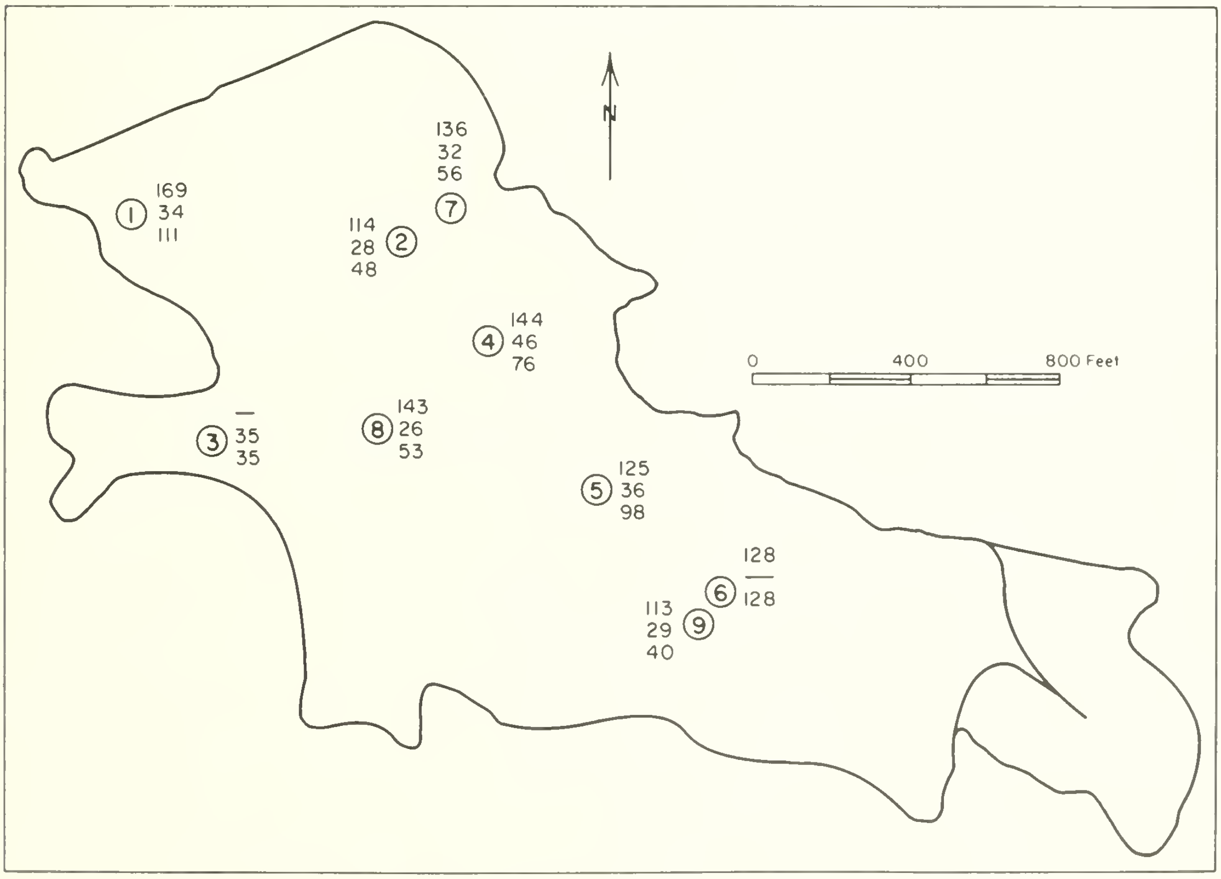


Fig. 9D - Zn (ppm) sampled at all sites.

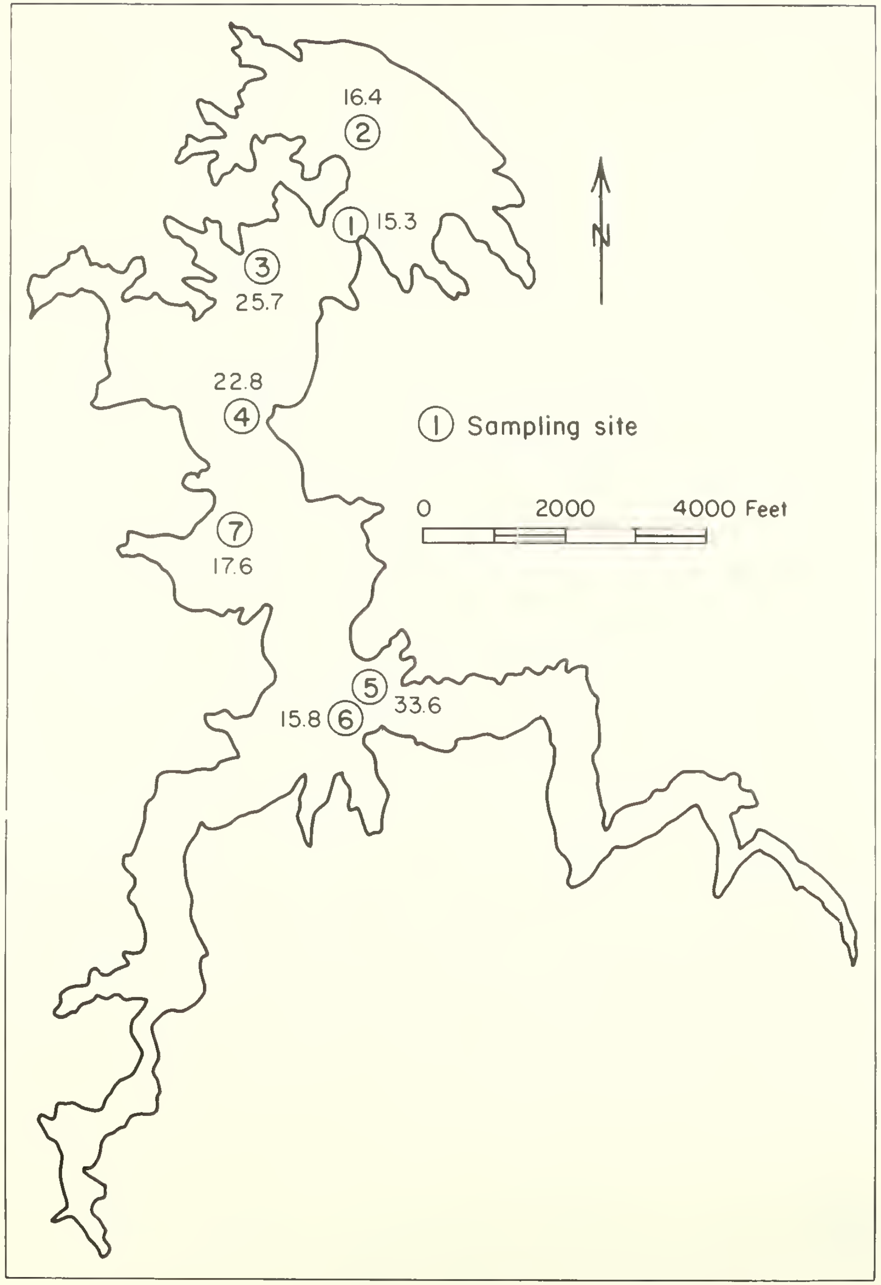


Fig. 10A - <2 µm clay (%) sampled at all sites.

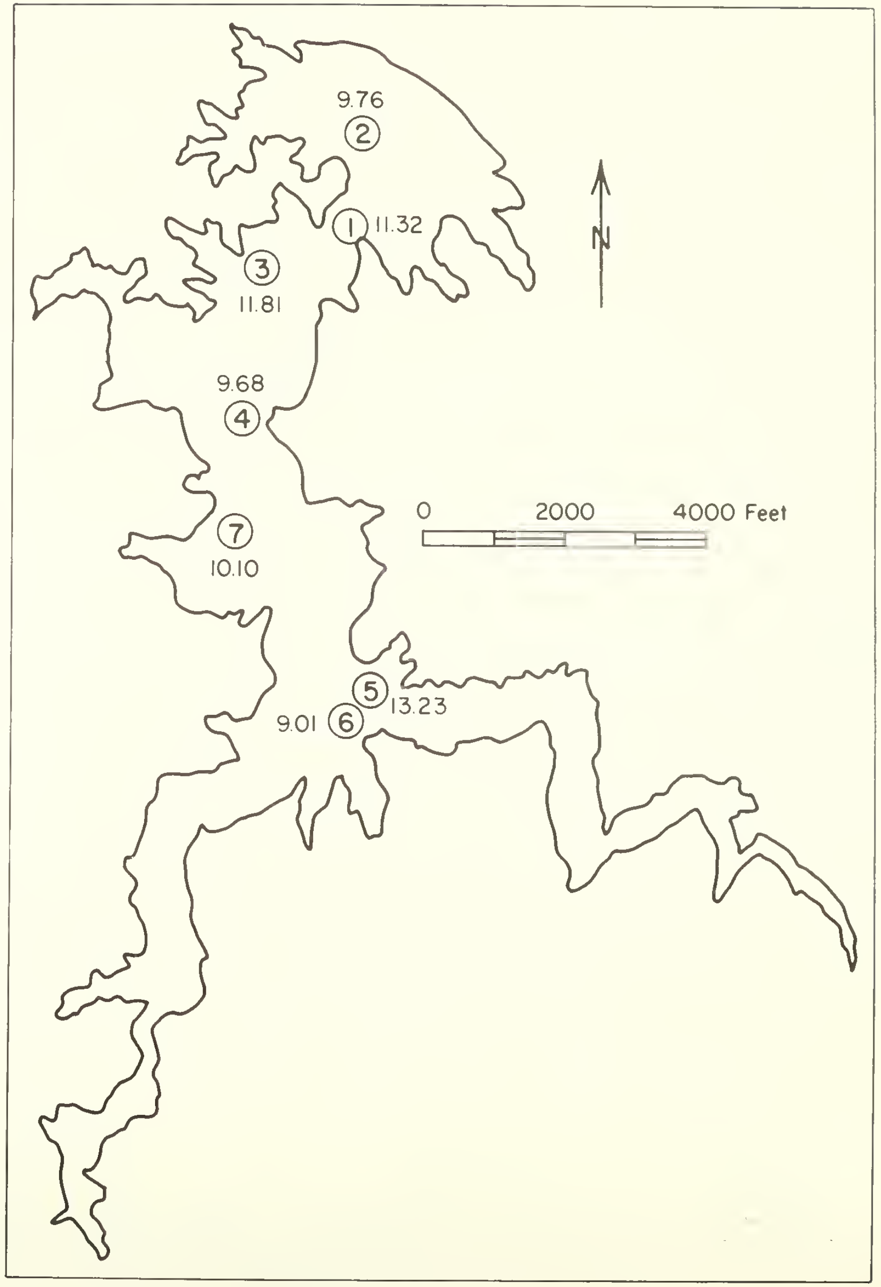


Fig. 10B - Al_2O_3 (%) sampled at all sites.

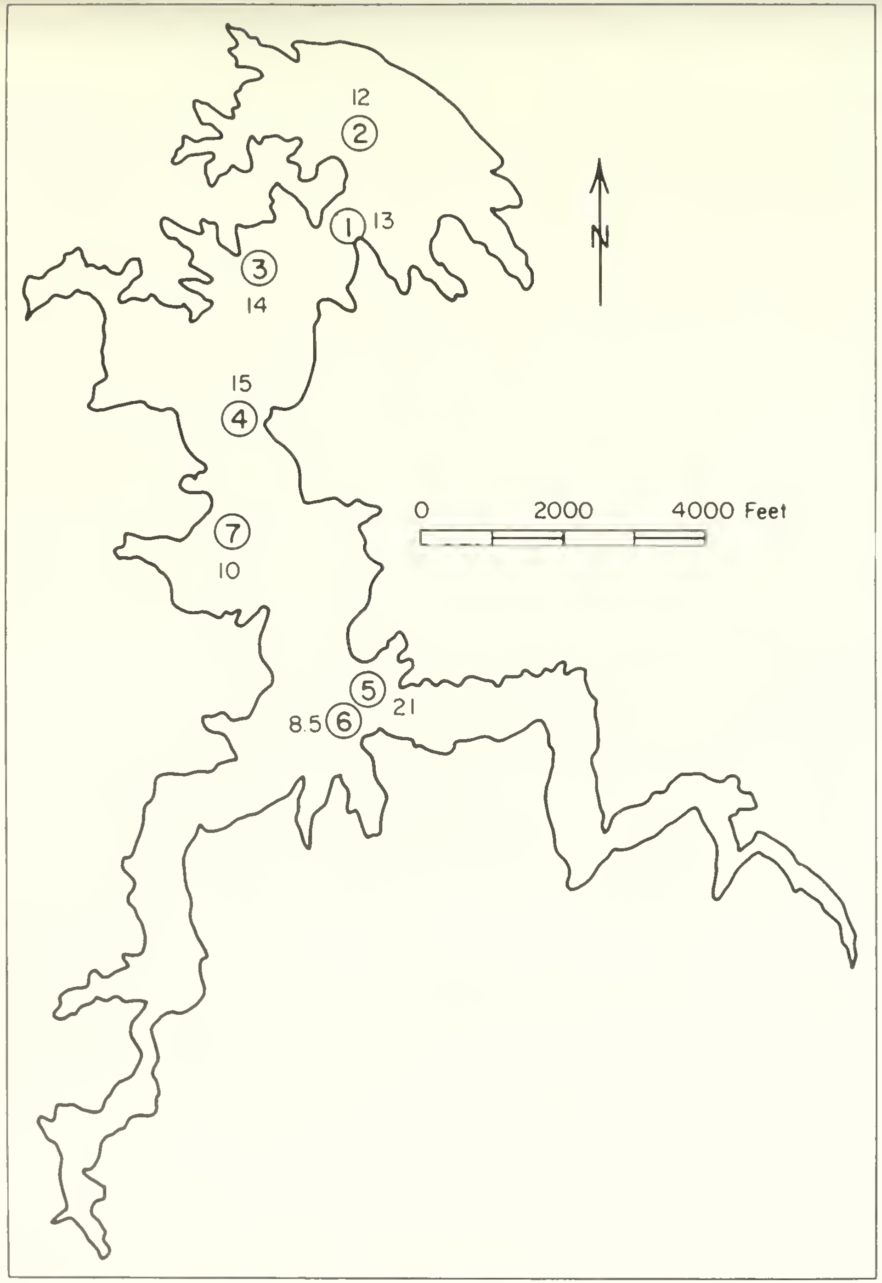


Fig. 10C - Cu (ppm) sampled at all sites.

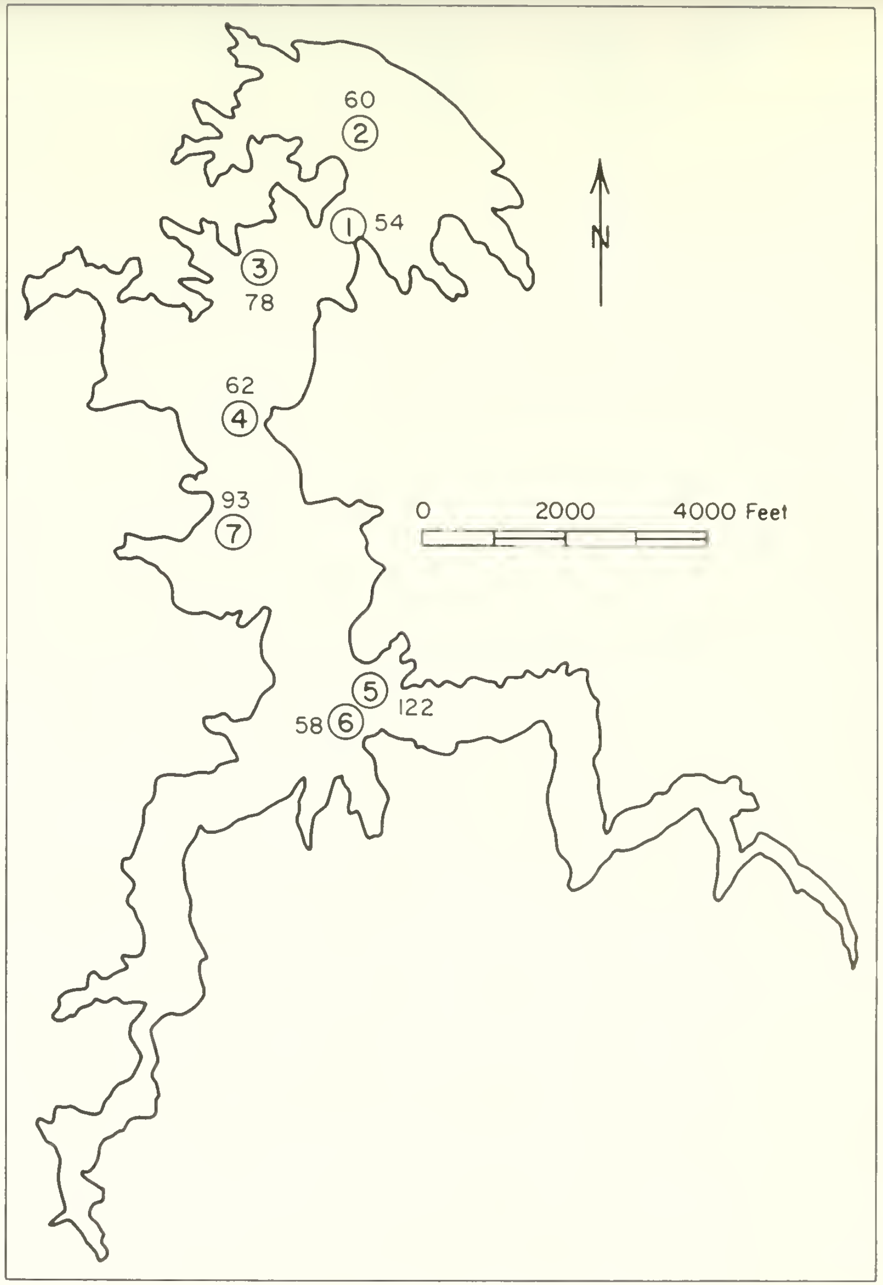


Fig. 10D - Zn (ppm) sampled at all sites.

Fig. 10A to D - Areal distribution in Little Grassy Lake.

In Johnston City Lake the areal distributions reveal increasing downstream concentrations of clay content, Fe_2O_3, P_2O_5, Co, Ni, and V, while SiO_2 and Ca have decreasing concentrations downstream in the upper sediment portions because the fine-grained clayey sediment is carried further into the lake. The concentrations of Al_2O_3, K_2O, TiO_2, and MnO are generally constant in the upper and lower portions, and SiO_2, MgO, Be, and Zr have rather constant mean concentrations in the lower portions. All other constituents are randomly distributed.

In Little Grassy Lake the mean concentrations of SiO_2, Al_2O_3, K_2O, TiO_2, MnO, and Ni are relatively constant, and all other constituents are randomly distributed.

Comparing the mean concentrations of some of the constituents found in sediments of these three lakes with those from Peoria Lake (Collinson and Shimp, 1972), Lake Michigan (Shimp, Leland, and White, 1970), and Lake Saline (Frye and Shimp, 1973) (table 8) suggests that most of the constituents from Little Grassy Lake and the lower sediment portions from Lake Du Quoin and Johnston City Lake are present at levels similar to those in ancient Lake Saline, particularly the overwash and slackwater deposits and the Farmdale Soil portions.

If the lower portions of sediments from Lake Du Quoin and Johnston City Lake represent the original lake bottoms, then the conclusion might be made that the concentrations found below the clay break are background or natural concentrations. A similar conclusion has been made for portions of Lake Michigan sediments (Shimp, Leland, and White, 1970) and for ancient Lake Saline sediments (Frye and Shimp, 1973). From this hypothesis and from a knowledge of the clay content in the upper (fine-grained) portions of sediments from these three lakes, we can obtain a possible measure of the extent of man-made pollution in the areas of the lakes.

Acknowledgments

Total carbon analyses were performed by Renée Gracon, carbon dioxide analyses by David B. Heck, X-ray fluorescence spectrometry by Leonard R. Henderson and John K. Kuhn, grain size analyses by Mary C. Charles, and clay mineral analyses by H. D. Glass. E. Donald McKay and Leon R. Follmer helped to interpret some of the data. Philip K. Hopke of the University of Illinois Institute of Environmental Studies provided the factor and cluster analyses.

TABLE 8 - MEANS AND RANGES OF MAJOR, MINOR, AND TRACE ELEMENT CONCENTRATIONS IN SEDIMENTS FROM PEORIA LAKE, LAKE MICHIGAN, LAKE SALINE, LAKE DU QUOIN, JOHNSTON CITY LAKE, AND LITTLE GRASSY LAKE[a]

	Air-dry weight in parts per million							
Sediment source	B	Be	Co	Cr	Cu	Ni	V	Zn
Peoria Lake[b]	36	2.7	12	151	62	54	78	446
	10-52	1.8-4.0	6-17	64-261	22-88	18-77	22-113	185-667
	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)
Lake Michigan[c]:	41	1.8	13	77	37	34	48	206
Top interval[d]	14-71	0.6-3.0	7-24	35-165	9-75	18-58	7-83	58-519
(0 to 10 cm)	(21)	(24)	(22)	(24)	(22)	(24)	(24)	(22)
Lake Michigan[c]:	48	1.7	14	52	20	35	62	66
	17-71	0.7-3.2	6-22	32-68	8-29	12-54	26-99	22-129
All intervals >15 cm but <100 cm	(24)	(23)	(23)	(24)	(24)	(23)	(23)	(23)
Lake Saline:	20	2.5	14	27	21	25	32	76
	13-28	2.2-2.8	13-16	22-32	16-25	18-31	24-48	49-95
Overwash and slack-water deposits. Cottage Grove and Equality Old Bridge	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Lake Saline:	41	2.5	13	24	25	22	35	70
	18-66	1.2-4.3	5-29	14-37	18-39	10-27	18-63	48-106
Altonian and Woodfordian	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Lake Saline:	17	2.9	12	33	16	23	40	89
	10-30	1.9-3.7	8-21	22-54	13-22	19-30	28-60	63-115
Farmdalian	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Lake Du Quoin:	48	3.1	15	63	304	32	87	192
	38-82	1.9-4.4	9-18	54-75	98-476	24-45	50-134	140-252
Upper portion	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
Lake Du Quoin:	78	2.2	9.3	41	20	20	41	70
	51-96	1.4-3.4	4.8-18	32-56	<3.0-211	11-30	23-81	42-138
Lower portion	(28)	(28)	(28)	(28)	(28)	(28)	(28)	(28)
Johnston City Lake:	45	5.4	16	64	56	45	126	139
	23-73	3.4-7.4	10-22	54-79	11-238	24-61	63-171	60-259
Upper portion	(35)	(35)	(35)	(35)	(35)	(35)	(35)	(35)
Johnston City Lake:	80	3.6	8.0	40	6.6	22	49	33
	49-117	2.3-5.2	3.6-16	22-66	3.4-31	15-94	26-126	18-104
Lower portion	(61)	(61)	(61)	(61)	(61)	(61)	(61)	(61)
Little Grassy Lake	81	2.6	11	50	14	28	70	78
	53-112	1.4-5.7	3.5-19	31-69	7.0-32	18-43	23-112	46-172
	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)

TABLE 8 - Continued

Sediment source	Oven-dry (110°C) weight in percent						
	MnO	P_2O_5	SiO_2	Fe_2O_3	CaO	CO_2	<2 µ clay
Peoria Lake[b]	0.084	0.69	59.8	4.81	4.91	4.90	--
	0.046-0.113	0.18-1.22	56.1-69.0	2.61-5.77	3.70-7.49	3.52-7.66	12-31
	(15)	(15)	(15)	(15)	(15)	(15)	(15)
Lake Michigan[c]:	0.072	0.15[e]	53.1[f]	4.04[f]	7.83[f]	10.81[f]	30[g]
	0.025-0.212	<0.01-0.42	40.2-70.2	2.09-9.99	4.37-15.90	5.16-20.69	10-69
Top interval[d] (0 to 10 cm)	(25)	(56)	(24)	(24)	(24)	(24)	(25)
Lake Michigan[c]:	0.050	0.17[eh]	48.4[f]	3.56[f]	9.14[f]	11.57[f]	40[g]
	0.027-0.110	<0.01-0.46	41.5-58.9	1.74-5.99	3.37-15.00	3.17-19.36	11-65
All intervals >15cm but <100cm	(24)	(73)	(31)	(31)	(32)	(32)	(24)
Lake Saline:	0.072	0.23	75.25	4.61	0.49	0.24	--
Overwash and slackwater deposits.	0.070-0.090	0.16-0.28	71.3-80.7	3.25-5.29	0.18-0.70	0.10-0.37	--
Cottage Grove and Equality Old Bridge	(4)	(4)	(4)	(4)	(4)	(4)	--
Lake Saline:	0.060[e]	0.66	51.8	4.79	9.94	10.07	∿45
	ND[i]-0.150	0.27-1.36	41.4-66.2	2.87-8.91	2.74-16.50	1.32-17.70	25-60
Altonian and Woodfordian	(12)	(12)	(12)	(12)	(12)	(12)	(10)
Lake Saline:	0.060	0.41	77.9	3.65	0.58	0.20	--
	0.020-0.140	0.06-0.63	74.7-82.9	1.65-6.66	0.36-0.89	0.02-0.42	--
Farmdalian	(3)	(3)	(3)	(3)	(3)	(3)	--
Lake Du Quoin:	.079	0.23	64.7	4.92	0.61		48
	.052-.145	0.11-0.39	58.9-75.7	3.31-6.32	0.37-0.80		26-68
Upper portion	(20)	(20)	(20)	(20)	(20)		(20)
Lake Du Quoin:	.032	.07	80.6	2.12	0.47		18
	.009-.070	.03-.16	73.6-86.5	1.54-5.12	0.38-0.90		12-39
Lower portion	(28)	(28)	(28)	(28)	(28)		(28)
Johnston City Lake:	.084	0.17	62.8	5.86	0.39		42
	.046-.112	.07-.27	48.0-70.0	3.30-7.37	0.07-0.65		16-64
Upper portion	(35)	(35)	(35)	(35)	(35)		(35)
Johnston City Lake:	.033	.052	83.2	2.11	0.28		18
	.012-.070	.001-0.15	66.9-87.8	1.45-5.15	.02-0.52		8-48
Lower portion	(61)	(61)	(61)	(61)	(61)		(61)
Little Grassy Lake	.060	0.10	78.1	3.68	0.42		22
	.032-.104	.02-.24	65.9-86.0	2.13-6.71	0.22-0.88		9-47
	(50)	(50)	(50)	(50)	(50)		(50)

---

[a] Values in parentheses = number of determinations used for calculating the mean.

[b] Data from Collinson and Shimp, 1972.

[c] Data from Shimp, Leland, and White, 1970; and Shimp et al., 1971.

[d] Top interval sediments selected to contain ≥ 0.75% organic carbon and ≥ 10% less than 2 µ clay-size material.

[e] "Less-than" values are not included in the mean.

[f] Data from Frye and Shimp, 1973.

[g] Data from Shimp et al., 1971.

[h] Greater than 10.5 cm interval.

[i] Not detected.

REFERENCES

Collinson, Charles, and N. F. Shimp, 1972, Trace elements in bottom sediments from Upper Peoria Lake, Middle Illinois River—a pilot project: Illinois State Geological Survey Environmental Geology Note 56, 21 p.

Frye, J. C., and N. F. Shimp, 1973, Major, minor, and trace elements in sediments of late Pleistocene Lake Saline compared with those in Lake Michigan sediments: Illinois State Geological Survey Environmental Geology Note 60, 13 p.

O'Connor, T. P., and D. R. Kester, 1975, Adsorption of copper and cobalt from fresh and marine systems: Geochimica et Cosmochimica Acta, v. 39, p. 1531-1543.

Shimp, N. F., H. V. Leland, and W. A. White, 1970, Distribution of major, minor, and trace constituents in unconsolidated sediments from southern Lake Michigan: Illinois State Geological Survey Environmental Geology Note 32, 19 p.

Shimp, N. F., J. A. Schleicher, R. R. Ruch, D. B. Heck, and H. V. Leland, 1971, Trace element and organic carbon accumulation in the most recent sediments of southern Lake Michigan: Illinois State Geological Survey Environmental Geology Note 41, 25 p.

Stall, J. B., J. B. Fehrenbacher, L. J. Bartelli, G. O. Walker, E. L. Sauer, and S. W. Melsted, 1954, Water and land resources of the Crab Orchard Lake Basin: Illinois State Water Survey Bulletin No. 42, 53 p.

Stiff, M. J., 1971, Copper/bicarbonate equilibria in solutions of bicarbonate ion at concentrations similar to those found in natural water: Water Research, v. 5, p. 171-176.

ENVIRONMENTAL GEOLOGY NOTES SERIES

(Exclusive of Lake Michigan Bottom Studies)

13. Geologic Factors in Dam and Reservoir Planning. 1966.
17. Selection of Refuse Disposal Sites in Northeastern Illinois. 1967.
19. Geology and Engineering Characteristics of Some Surface Materials in McHenry County, Illinois. 1968.
23. Effects of Waste Effluents on the Plasticity of Earth Materials. 1968.
24. Notes on the Earthquake of November 9, 1968, in Southern Illinois. 1968.
25. Preliminary Geological Evaluation of Dam and Reservoir Sites in McHenry County, Illinois. 1969.
27. Evaluating Sanitary Landfill Sites in Illinois. 1969.
34. Sulfur Reduction of Illinois Coals—Washability Tests. 1970.
42. A Geologist Views the Environment. 1971.
43. Mercury Content of Illinois Coals. 1971.
45. Summary of Findings on Solid Waste Disposal Sites in Northeastern Illinois. 1971.
48. Landslides Along the Illinois River Valley South and West of La Salle and Peru, Illinois. 1971.
49. Environmental Quality Control and Minerals. 1971.
50. Petrographic Properties of Carbonate Rocks Related to Their Sorption of Sulfur Dioxide. 1971.
51. Hydrogeologic Considerations in the Siting and Design of Landfills. 1972.
52. Preliminary Geologic Investigations of Rock Tunnel Sites for Flood and Pollution Control in the Greater Chicago Area. 1972.
53. Data from Controlled Drilling Program in Du Page, Kane, and Kendall Counties, Illinois. 1972.
56. Trace Elements in Bottom Sediments from Upper Peoria Lake, Middle Illinois River—A Pilot Project. 1972.
57. Geology, Soils, and Hydrogeology of Volo Bog and Vicinity, Lake County, Illinois. 1972.
59. Notes on the Earthquake of September 15, 1972, in Northern Illinois. 1972.
60. Major, Minor, and Trace Elements in Sediments of Late Pleistocene Lake Saline Compared with Those in Lake Michigan Sediments. 1973.
61. Occurrence and Distribution of Potentially Volatile Trace Elements in Coal: An Interim Report. 1973.
62. Energy Supply Problems for the 1970s and Beyond. 1973.
63. Sedimentology of a Beach Ridge Complex and Its Significance in Land-Use Planning. 1973.
64. The U.S. Energy Dilemma: The Gap Between Today's Requirements and Tomorrow's Potential. 1973.
65. Survey of Illinois Crude Oils for Trace Concentrations of Mercury and Selenium. 1973.
66. Comparison of Oxidation and Reduction Methods in the Determination of Forms of Sulfur in Coal. 1973.
67. Sediment Distribution in a Beach Ridge Complex and Its Application to Artificial Beach Replenishment. 1974.
68. Lake Marls, Chalks, and Other Carbonate Rocks with High Dissolution Rates in SO_2-Scrubbing Liquors. 1974.
70. Land Resource—Its Use and Analysis. 1974.
71. Data from Controlled Drilling Program in Lee and Ogle Counties, Illinois. 1974.
72. Occurrence and Distribution of Potentially Volatile Trace Elements in Coal: A Final Report. 1974.
73. Illinois Geology from Space. 1975.
75. Data from Controlled Drilling Program in Kane County, Illinois. 1975.
77. Data from Controlled Drilling Program in Boone and De Kalb Counties, Illinois. 1976.
78. Attenuation of Pollutants in Municipal Landfill Leachate by Clay Minerals. Part I—Column Leaching and Field Verification. 1976.
79. Attenuation of Pollutants in Municipal Landfill Leachate by Clay Minerals. Part II—Heavy-Metal Adsorption. 1977.
81. Ground-Water Contamination: Problems and Remedial Action. 1977.

NOTE: Out of print publications are not listed. They are available for examination from most public, college, and university libraries.

BOUND BY